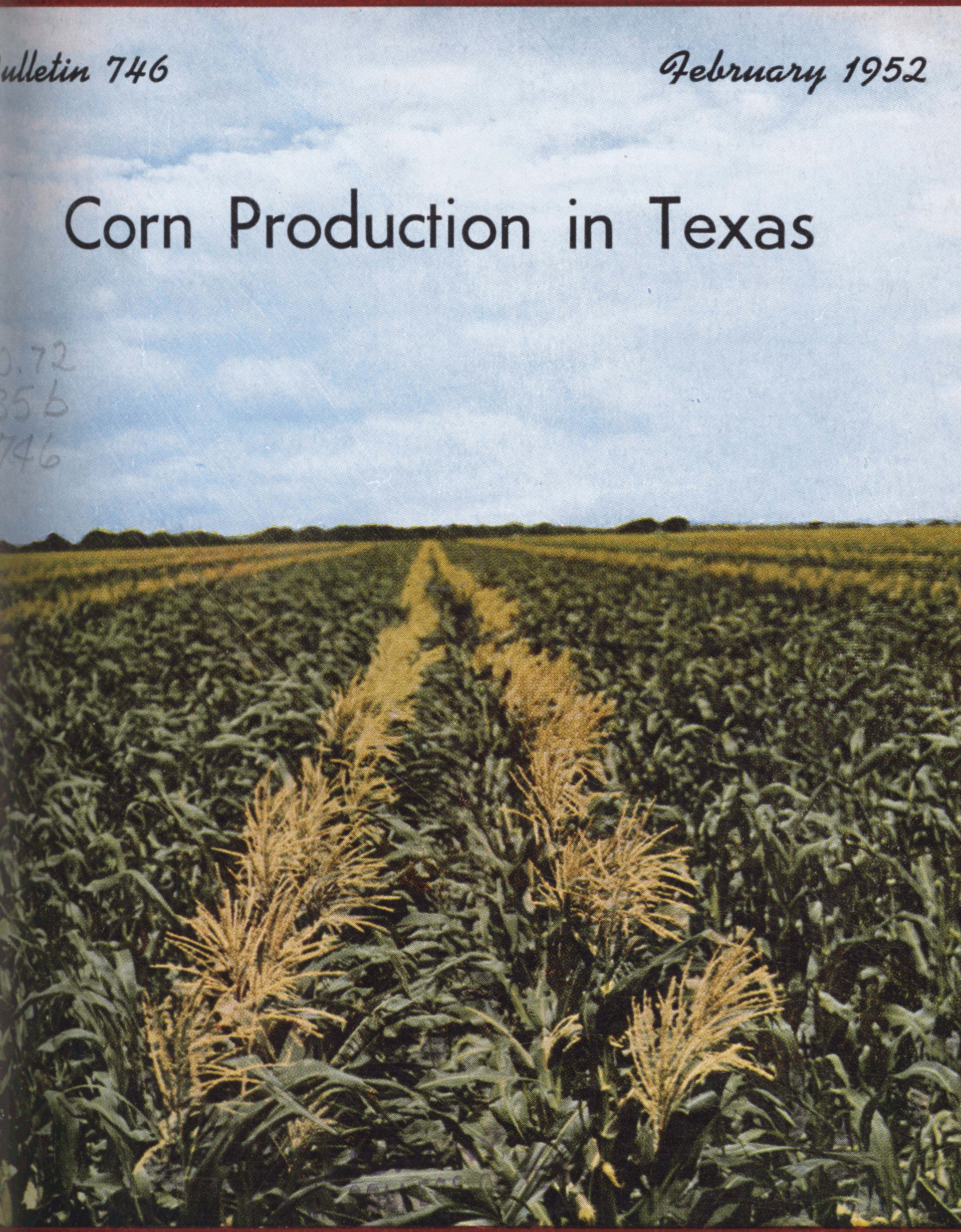
TEXAS AGRICULTURAL EXPERIMENT STATION
R. D. LEWIS, Director, College Station, Texas

Bulletin 746 February 1952

Corn Production in Texas



The TEXAS AGRICULTURAL AND MECHANICAL COLLEGE SYSTEM
GIBB GILCHRIST, Chancellor

TABLE 1. RECOMMENDATIONS BY SOIL AREAS FOR CORN PRODUCTION IN TEXAS

Soil areas	Planting dates	Plants per acre	Spacing, inches in row	Fertilizer at planting time[1]	Side-dressing of nitrogen[2]	Soil-improving legumes	Hybrids
East Texas Timber Country and sandy soils of the Gulf Coast Prairie	Mar. 5-30	6,500-9,000	18-24	30-40-30	60	Hairy vetch, Singletary peas, Austrian winter peas, Lespedeza	28, 26, 20, 24, 30
Gulf Coast Prairie (clay soils)	Mar. 15-Apr. 15	9,000	18	30-40-0	40	Melilotus indica, Hubam and Madrid sweetclovers	11W, 24, 30
Blackland Prairie	Mar. 1-20	6,500-9,000	18-24	30-40-0	30	Hubam, Madrid and Evergreen sweetclovers	28, 26, 30
Grand Prairie	Mar. 1-20	6,500	24	30-40-0	30	Hubam, Madrid and Evergreen sweetclovers	28, 26
West Cross Timbers	Mar. 15-30	6,500	24	15-30-15	30	Hairy vetch, Hubam and Madrid sweetclovers	28, 26
Rio Grande Plain (Dry-land)	Feb. 15-Mar. 1	5,000-6,500	24-30	15-30-0	30	Hubam clover and Melilotus indica	24, 26
Rio Grande Plain (Irrigated)	Feb. 1-15	13,000	12	30-80-0	90	Hubam clover and Melilotus indica	24
Rolling Plains	Mar. 25-Apr. 10	6,500	24	15-45-15	30	Alfalfa, hairy vetch, Hubam and Madrid sweetclovers	26, 20, 28
High Plains (Irrigated)	Apr. 10-May 1	9,000	18	30-0-0	30	Alfalfa, hairy vetch, Hubam and Madrid sweetclovers	28

[1]Shown as pounds per acre of nitrogen (N), phosphoric acid (P_2O_5) and potash (K_2O), respectively.
[2]Shown as pounds per acre of nitrogen (N).

DIGEST

Corn is one of the more important grain crops grown in Texas. It ranks fourth in acreage among all farm crops. In recent years, approximately 3,000,000 acres annually have been devoted to corn production, and the average yield has ranged from 16.5 to 22.5 bushels per acre. Considerably higher yields are obtained with the use of improved cultural practices and adapted hybrids. The proportion of the corn acreage planted to adapted hybrids has expanded from less than 1 percent in 1941 to 65 percent in 1951.

Proper cultural practices, with particular emphasis on optimum plant number, adequate fertilization and the use of soil-improving crops are essential in obtaining maximum and economical yields of corn. The importance of these various practices is discussed in this bulletin and recommendations are given for corn production in the different areas of the State.

Numerous diseases and insects attack corn in Texas and are responsible for considerable damage to the crop. These organisms are especially prevalent during wet seasons, and they may cause appreciable damage each year in the more humid sections. Hybrids such as Texas 24 and 30, which possess some resistance, should be used where diseases and insects are a serious problem.

The Texas hybrid corn breeding program, which was initiated in 1927, has resulted in the development of several adapted hybrids capable of yielding 20 to 30 percent more than the open-pollinated varieties previously grown. Texas 24, 26, 28 and 30 are the best yellow hybrids now available, while Texas 11W is the leading white hybrid.

Tests are conducted each year at numerous locations throughout the corn-growing regions of Texas to compare the performance of commercial hybrids. Results of these tests are discussed according to soil areas, and particular hybrids are recommended for each area on the basis of their performance. Summary results by individual test locations are presented in tabular form on pages 69 to 73.

Recommendations concerning the important practices responsible for maximum corn production in Texas are summarized in Table 1 on the opposite page. These recommendations are too specific to be applied under all conditions encountered in an area, but they should provide a basis for developing general practices which could be followed to advantage in any particular area.

Shown on the front cover is a detasseled double-cross production field. The back cover shows the method of producing single and double-cross corn hybrids.

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BULLETIN 746 MARCH 1952

Corn Production in Texas

JOHN S. ROGERS AND JESSE W. COLLIER*

CORN IS ONE of the more important field crops grown in Texas. Along with grain sorghum it furnishes the major portion of the feed grain produced in the State. Among farm crops, the corn acreage has been exceeded in recent years only by that of cotton, grain sorghum and wheat. Corn growing is confined largely to the eastern and central parts of the State, where moisture conditions are relatively favorable for corn production, but limited acreages also occur in certain areas of West Texas. Figure 1 shows that most of the Texas corn crop is grown east of the 30-inch rainfall belt.

Annual Texas corn production is about 60,000,000 bushels. This amount fluctuates somewhat as a result of changing acreages and variable weather conditions. Approximately three-fourths of the total corn crop is now fed as grain on the farms where it is produced. There is a growing tendency, however, for a large proportion to be sold to local buyers soon after harvest. Less than 1 percent of the total Texas corn acreage is harvested as silage or forage. About 1 percent of the annual corn crop is used for human consumption.

In total corn acreage, Texas ordinarily ranks among the leading states, but in recent years there has been a marked decline as a result of expanded sorghum and cotton acreages. Figure 2 shows the annual acreages for the period, 1900-50. During most of this time the total acreage varied between 4,000,000 and 5,000,000, with the exception of a brief period around 1925 when cotton prices were unusually high. A detailed estimate of the annual harvested acreages for the period 1941-51 is shown in Table 2. These data indicate that about 3,000,000 acres probably will be devoted to corn production under prevailing agricultural and economic conditions. Future corn acreages will depend primarily on the relative value of competing crops such as cotton and grain sorghums. Since the cotton acreage is now near a maximum, it does not seem likely that the corn acreage will decrease much below the present level, and it could increase in the event of a reduction in cotton planting.

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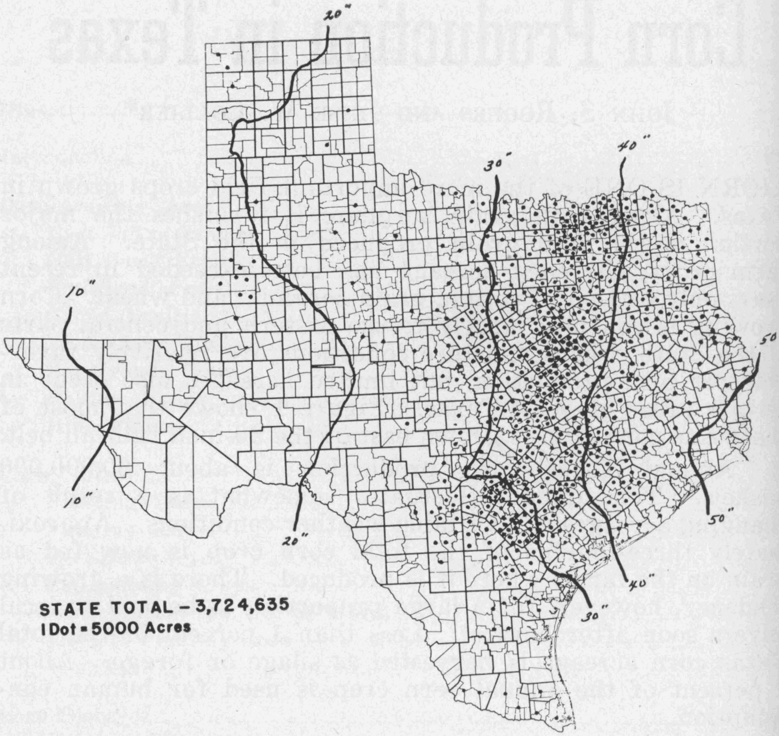

Figure 1. Rainfall belts and distribution of corn acreages in Texas in 1944.

Despite the rather large acreage devoted to corn each year, the total Texas production is limited by the low average yield per acre. For 1941-51, as shown in Table 2, this figure approximated only 17 bushels, while for the period from 1900-50, Figure 2, the average yield usually fluctuated between 10 and 20 bushels per acre. Yields were slightly higher at the beginning of the century as a result of inherent soil fertility. With continued cropping, however, fertility and yields gradually declined. The annual fluctuations in yield are due to variations in rainfall during the growing season in the different years.

Insufficient moisture during the latter part of the growing season is usually the limiting factor to corn production in Texas, although it may be minimized by the proper use of fertilizers and soil-improving crops, and the planting of the best-adapted hybrids. Excessive rainfall during the early part of the growing season may also reduce corn yields, a fact which makes it especially desirable to select a well-drained soil for corn production. Actually, corn is planted on a wide variety of soils ranging in type from heavy clays to coarse sands. Satisfactory yields may be obtained on most of the major soil types with the use of recommended cultural practices; however, fertile, well-drained loamy soils ordinarily produce the best yields. Widespread acceptance of improved cultural practices and adapted hybrids would unquestionably result in a marked increase in the average per-acre yield of corn, and make corn production a more profitable venture for Texas farmers.

The development of adapted corn hybrids in recent years offers Texas farmers a readily available means of increasing their corn yields. Experience in other corn-growing regions of the United States shows that increases in yield of approximately 20 percent over the open-pollinated varieties may be expected from the use of adapted hybrids. Results so far in Texas are in general agreement with this figure. In fact, increases greater than 20 percent are frequently reported. Figure 3 shows the rapid acceptance of adapted hybrids in Texas as a result of their ability to produce increased yields. Table 2 shows that a pronounced shift from open-pollinated varieties to hybrids has occurred within the past 11 years. Less than 1 percent of the 1941 corn acreage was planted to hybrids, while by 1951 this figure had risen to 65 percent. Since the hybrid acreage is still expanding, more than three-fourths of the Texas corn acreage soon should be planted to corn hybrids.

TABLE 2. TOTAL CORN ACREAGE, CORN HYBRID ACREAGE, PERCENTAGE OF ACREAGE PLANTED TO CORN HYBRIDS AND AVERAGE YIELD OF CORN IN TEXAS, 1941-51

Year	Harvested acreage	Hybrid acreage	Percentage planted to hybrids	Average yield, bu. per acre
1941	4,546,000	31,820	0.7	15.0
1942	4,910,000	58,920	1.2	14.5
1943	4,714,000	70,710	1.5	16.0
1944	3,960,000	118,800	3.0	14.4
1945	3,406,000	401,908	11.8	16.0
1946	3,236,000	744,280	23.0	17.0
1947	2,945,000	1,060,200	36.0	16.5
1948	2,709,000	1,368,045	50.5	16.5
1949	2,587,000	1,319,370	51.0	22.5
1950	2,921,000	1,664,970	57.0	21.0
1951	2,278,000	1,480,700	65.0	18.5
Ave.	3,483,000			17.1

Data from the Bureau of Agricultural Economics, U. S. Department of Agriculture.

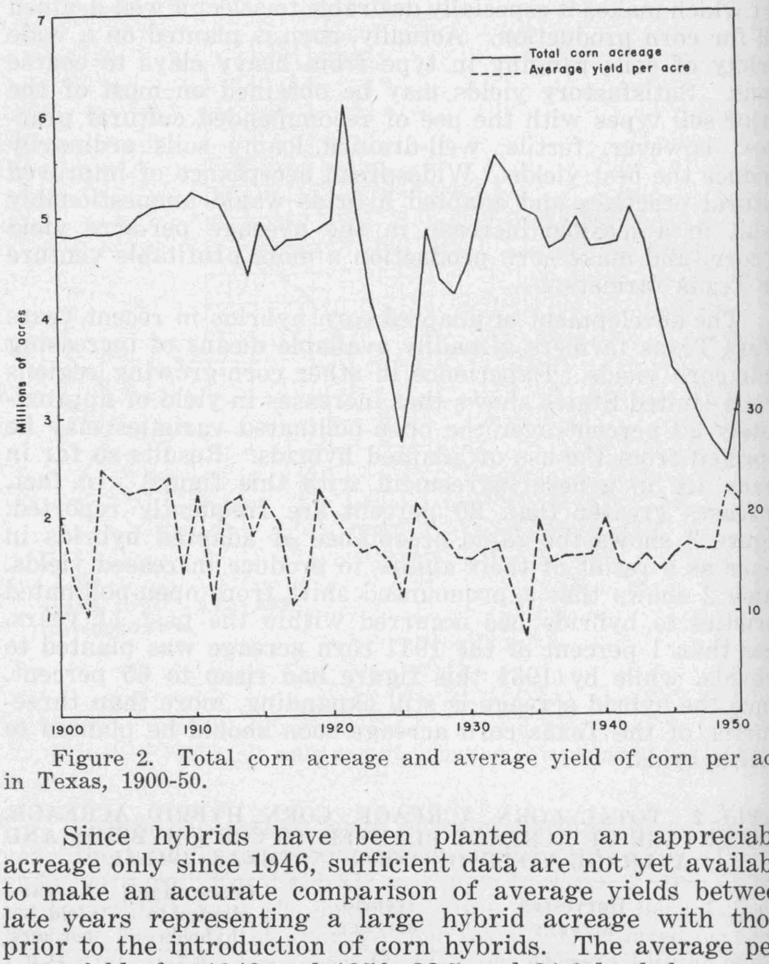

Figure 2. Total corn acreage and average yield of corn per acre in Texas, 1900-50.

Since hybrids have been planted on an appreciable acreage only since 1946, sufficient data are not yet available to make an accurate comparison of average yields between late years representing a large hybrid acreage with those prior to the introduction of corn hybrids. The average per-acre yields for 1949 and 1950, 22.5 and 21.0 bushels, respectively, afford some evidence, however, that the widespread use of corn hybrids is effecting an increase in Texas corn production. These were the highest average yields for the past 25 years. When data are available for a longer period, it should be possible to determine the approximate increase in production resulting from the extensive use of corn hybrids. It seems reasonable to conclude that the use of hybrids from 1948 to 1951, when they were planted on at least 50 percent of the total corn acreage, resulted in the production of an additional 6,000,000 to 8,000,000 bushels annually over what might have been obtained with open-pollinated varieties.

CORN-GROWING AREAS

Corn is grown in Texas under a wide range of environmental conditions. Any discussion of the various factors affecting corn production, therefore, should be on an area basis. The soil areas defined in Bulletin 431 of the Texas Agricultural Experiment Station are used in this bulletin as a basis for reporting results and recommending practices. The various soil areas, as well as the locations where corn performance tests are conducted, are given in Figure 4. A brief description is included of the areas where corn is grown, and special emphasis is given to the factors affecting corn production in each area.

East Texas Timber Country

The East Texas Timber Country is irregular in topography and much of the land is covered with timber. As a result, the cultivated acreage is low in proportion to the total

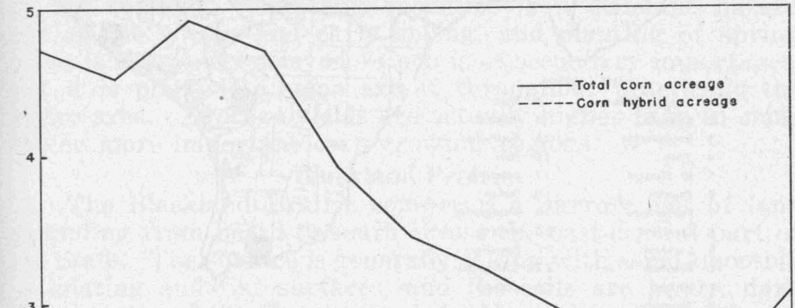

Figure 3. Total corn and corn hybrid acreages in Texas, 1940-50.

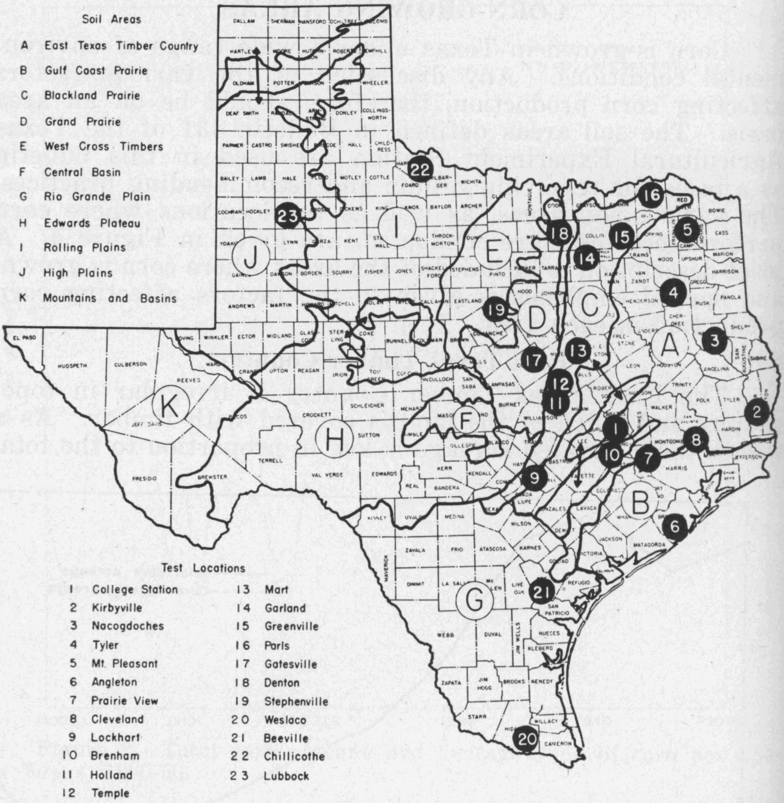

Figure 4. Texas soil areas and corn performance test locations.

area. Most fields are only a few acres in size. The soils consist mainly of loamy fine sands and fine sandy loams, but they include a large number of different series ranging from fine sands to clay loams. The entire area is low in organic matter, and most soils are medium to strongly acid and deficient in the more important essential mineral elements. Nitrogen, in particular, is usually below the minimum level for optimum crop production. Rainfall in this region is higher than in other parts of the State, with the exception of a part of the Gulf Coast, and sufficient moisture is usually available to produce good yields of corn. Drouth conditions may be encountered during the latter part of the growing season, however, when temperatures are high and rainfall is comparatively low. Corn is probably the most important cultivated crop grown in the East Texas Timber Country, and excellent yields may be obtained with the use of adequate fertilization, proper cultural methods and adapted hybrids. Higher rainfall and a consistent response to fertilizers make it potentially the highest corn-yielding area in the State.

Gulf Coast Prairie

The Gulf Coast Prairie comprises a nearly flat strip of country 20 to 80 miles wide bordering the Gulf of Mexico. Drainage is very poor and a good portion of the area is not well adapted to row crops. The soils are primarily heavy, dark clays and clay loams, mostly of the Lake Charles series, which are inherently capable of high productivity. A narrow strip, ranging from 5 to 25 miles wide along the interior of the prairie, consists mainly of fine sandy loams of the Hockley and Katy series. These are moderately well drained and are well suited for row crops. Rainfall is sufficiently high during most of the season for the proper growth of crop plants, although drouth conditions may occur during the latter part of the summer. Excessive moisture is a constant hazard during the winter and early spring, and planting of spring crops is frequently delayed. Corn is of secondary importance, but it is planted to some extent throughout practically the entire area. Average yields are actually higher than in some of the more important corn-growing regions.

Blackland Prairie

The Blackland Prairie comprises a narrow belt of land extending from north to south across the east-central part of the State. The surface is generally rolling with some smoothly undulating and flat surfaces, and the soils are heavy, dark clays mostly of the Houston and Austin series. The soils are dominantly calcareous and inherently productive, but continued soil erosion and cropping have considerably reduced their yielding capacity. The Blackland Prairie is an intensive agricultural area and a very large proportion of the land is devoted to cultivated crops. Rainfall is inadequate for optimum crop production, since summer drouths may be expected to curtail yields to some extent practically every year. This is now the most important corn-growing region of the State, approximately 50 percent of the total corn acreage being located in this area. Within the area, however, corn is second to cotton in importance. Consistently good corn yields are obtained in the Blackland Prairie, but extremely high yields, such as those sometimes produced in East Texas, are exceedingly rare.

Grand Prairie

The Grand Prairie is just west of the Blackland Prairie. In many respects, the two areas are quite similar. The Grand

Prairie is somewhat rougher and has large areas of shallow soils and numerous hilly sections crossed by a number of deep valleys. Agriculturally, the area has not been developed as intensively as the Blackland Prairie. The soils are calcareous clays, ranging from black to brown in color, and belong primarily to the Denton and San Saba series. Rainfall is slightly less than in the Blackland Prairie, and summer drouths are more serious in limiting crop production. The soils of this region are relatively fertile, and moderate amounts of organic matter are present in the topsoil. Corn is one of the more important crops of the region, along with cotton, sorghum, oats and wheat. Fair yields may be expected in most years, although insufficient moisture during the latter part of the growing season prohibits exceptionally high yields.

West Cross Timbers

The West Cross Timbers is a timbered region in North-central Texas just west of the Grand Prairie. Most of the land surface is gently to very rolling, although considerable areas of hilly and rough stony lands occur in some sections. The predominating soils are sandy in texture. Only a small portion of the land is devoted to the production of farm crops, and most farms are small. This area is on the western edge of the humid region, and lack of rainfall severely limits crop production in most years. Corn is grown rather extensively in the eastern part, and to some extent throughout the entire area. Moderate yields may ordinarily be obtained.

Rio Grande Plain

The Rio Grande Plain is a broad undulating to rolling area in South Texas. The climate is relatively mild and the rainfall ranges from about 30 inches annually on the eastern edge to 20 inches on the western side. A good portion of the eastern part is in cultivation. Cotton and grain sorghum are the predominant crops. The soils vary from heavy, dark clays in the eastern part to lighter, sandier types in the southern and western sections. Included in the southern tip of this region is the Lower Rio Grande Valley. Corn is relatively unimportant in this region with the exception of a small strip on the eastern side. A limited acreage is also grown in the Lower Rio Grande Valley.

Rolling Plains

The Rolling Plains are in the west-central part of North Texas and consist of a large land area with a rolling surface. A wide range of soils, varying from dark brown to red in color and heavy clay to sand in texture, occurs in this area. The soils, in general, are highly productive, but the use of fertilizers is sometimes necessary for maximum production. The entire area is within the subhumid region and the limited rainfall is somewhat irregular. Cotton, grain sorghum, wheat and oats are the principal crops and corn is of minor importance. However, some corn is grown each year in the eastern part of the area.

High Plains

The High Plains in Northwest Texas occupy a vast plateau with a relatively smooth surface. The dark-colored soils of the area are primarily clay loams, while the red soils are mostly sandy in texture. Rainfall of the area is only 15 to 20 inches annually, and a considerable portion of the crop land is under irrigation from shallow wells. The soils are inherently productive and excellent crop yields may be obtained with irrigation. Cotton, wheat and grain sorghum are the principal crops, and only a limited amount of corn is grown. Practically all of the corn acreage is under irrigation because of the low natural rainfall.

CORN CULTURE

Cultural practices for corn are similar to those required for other row crops and are known by most farmers and agricultural workers. Seedbed preparation usually consists of some type of plowing with a disc or moldboard plow in the fall or winter, followed by harrowing and bedding and sometimes by rebedding. A modification of this method, commonly used in the Blackland and Grand Prairies, consists of shallow cultivation in the fall with a one-way plow or disc-harrow, followed by bedding and rebedding. Regardless of the method used in seedbed preparation, corn requires a seedbed that is deep, well pulverized, in good physical tilth and free of weeds at planting time. The yield of corn is determined before and at the time of planting to a much greater extent than most farmers realize.

On sandy soils, the seed are planted on low beds or on the level, while on the heavier clay soils, particularly in the Blackland and Grand Prairies, the seed ordinarily are planted on beds above the ground level. Flat planting on heavy clay soils often results in poor stands as the seed are damaged by poor drainage within the soil. The practice of "rolling corn" to hasten emergence and obtain better stands is common in areas where heavier soils predominate.

Cultivation of corn for weed control is especially important in Texas where rainfall is often inadequate and the fertility level is low. Under these conditions, the use of water and nutrients by weeds results in exceptionally low yields. The first cultivation is extremely important as it destroys the first crop of weeds and also increases the aeration of the soil around the corn roots. Ordinarily, the second cultivation is the deepest, while the remaining cultivations should be shallow to avoid damaging the root system. Two to four cultivations of the growing crop are usually required for proper weed control; the last cultivation should be made when the corn is approximately waist-high.

The use of machinery for harvesting the corn crop has increased rapidly in the past few years, especially in the more intensively cultivated areas such as the Blackland and Grand Prairies and the Rio Grande Plain. A large part of the crop is harvested in August and early September just as soon as the moisture content reaches 15 or 16 percent. This practice has several advantages over later harvesting. It results in a smaller loss from insects, diseases and weather hazards, enables the harvest to be done during a slack work season, and allows early land preparation for fall-seeded small grain or legume crops.

Planting Dates

One of the most important factors limiting corn production in Texas is inadequate moisture during the latter part of the growing season. Texas Bulletin 49, 1898, states the problem: "It must be clearly borne in mind that it is the last thirty days of growth that determines the success of corn in Texas." Thus, it is important that planting dates and rates enable the crop to be grown with the least injury possible from the summer drouths. Results reported in Texas Bulletin 397, 1929, show that early-planted corn is practically always more productive than late-planted corn, and that there is a definite relationship between the date of planting and the date of silking. These results also show that corn planted 10 days apart in March ordinarily silks only 5 days apart in June. In other words, the earlier the corn is planted the longer is the period between planting and silking. Although extra-early plantings may partially escape yield reductions from early summer drouths, the disadvantages of this practice are slow emergence, poor stands and possible frost injury after emergence. Since adequate stands are essential for maximum corn yields, extra-early plantings usually will be inferior in yield to plantings at medium dates. A rule adhered to by some successful corn growers is to wait until the upper six or eight inches of soil have an average daily temperature of about 50° F. before planting. This practice ordinarily insures more adequate stands, higher nutrient availability and better growing conditions. As a result, higher yields are

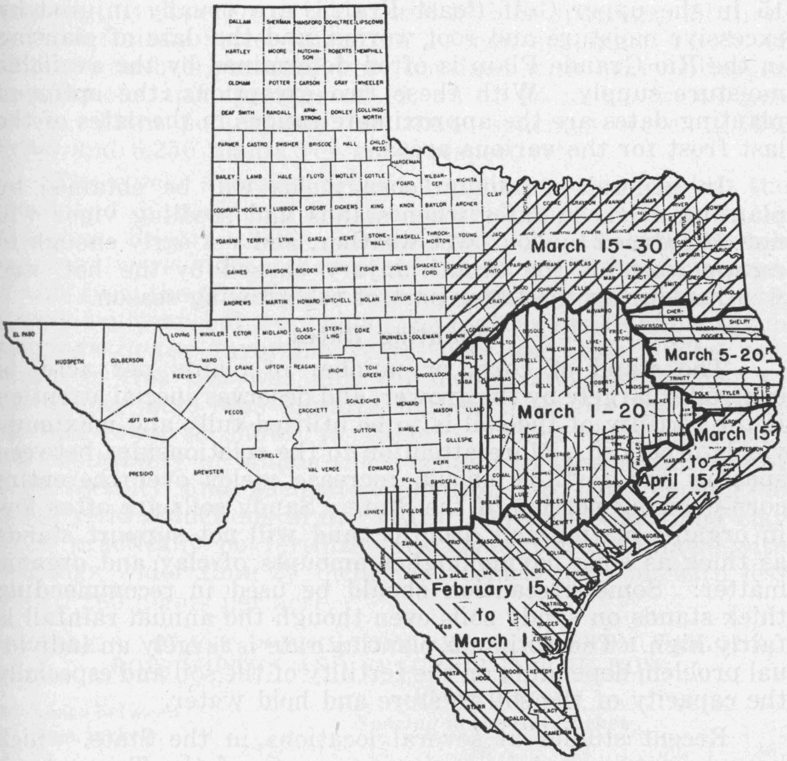

Figure 5. Recommended planting dates for the corn-growing areas of Texas.

usually obtained than by planting exceptionally early in an effort to escape drouth conditions.

Dates for corn planting in Texas are subject to both regional and seasonal variations, but in most areas of Texas planting is begun near the average date of the last frost. Approximate optimum planting dates for the various portions of the State are shown in Figure 5. These recommendations are based largely on results from earlier studies of planting dates as they affect corn yields, which also are reported in Texas Bulletin 397. Weather conditions permit corn to be planted as early as the latter part of January in the Lower Rio Grande Valley, while it may be delayed until the latter part of April or early May on the High Plains. Some of the acreage in the Rio Grande Plain, or southern corn-growing section, is planted in February, but most of the Texas corn crop is planted during March. Plantings earlier than March

15 in the upper Gulf Coast Prairie are usually injured by excessive moisture and root worms, and the date of planting in the Rio Grande Plain is often determined by the available moisture supply. With these two exceptions, the optimum planting dates are the approximate ranges in the dates of the last frost for the various areas.

In general, maximum corn yields will be obtained by planting at those dates when stands and seedling vigor will not be reduced by cold, wet weather, and yet early enough to escape some of the drouth injury caused by the hot, dry weather during the latter part of the growing season.

Planting Rates

The stand of corn, or number of plants per acre, is controlled largely by the grower, and deserves special attention if the fertility of the soil is to be utilized fully and maximum yields produced. More attention to the relationships between spacing and fertility should increase yields over the entire corn-growing portion of the State. Sandy soils are often low in organic matter and drouthy, and will not support stands as thick as soils having higher amounts of clay and organic matter. Some precaution should be used in recommending thick stands on sandy soils even though the annual rainfall is fairly high. The optimum planting rate is largely an individual problem depending on the fertility of the soil and especially the capacity of the soil to store and hold water.

Recent studies at several locations in the State, which have been reported in progress reports of the Texas Agricultural Experiment Station, show that the commonly-used spacings of 30 to 36 inches in the row (about 4,000 to 6,000 plants per acre) will not produce maximum corn yields. This is particularly apparent under favorable weather and optimum fertility conditions. Results from a corn fertility-spacing test near Kirbyville in 1950 are given in Progress Report 1307. The soil was a sandy loam and adequate rainfall was received. The best performance was obtained from a spacing of 24 inches in 40-inch rows, or about 6,500 plants per acre. Following heavy fertilization, yields were 65 to 75 bushels per acre with the 24-inch spacing.

Results of fertility and spacing studies conducted near College Station in 1949 and 1950 on heavy soils of the Brazos River bottom are given in Progress Report 1339. Yields from spacings of 12, 18 and 24 inches in the row were not significantly different in 1949, but all produced higher yields than the 30-inch spacing. In 1950, as a result of adequate moisture throughout the growing season, the 12-inch spacing was slightly superior to the 18 and 24-inch spacings; all three were definitely better than the 30-inch spacing. Yields of 85 to 95 bushels per acre were obtained with heavy nitrogen applications and spacings of 12, 18 or 24 inches in 40-inch rows. Plant populations for these spacings were 12,500, 8,300 and 6,250 plants per acre, respectively.

Three-year averages from a fertilizer-spacing test at the Blackland Experiment Station near Temple are given in Progress Report 1388. Yields from the 18 and 24-inch spacings were higher than from the 12 or 30-inch spacings. Yields from the 12-inch spacings were greatly reduced in 1948, a very dry year, but were almost as high as the 18 and 24-inch spacings in the favorable years 1949 and 1950. The row width in this test was only 36 inches, and the number of plants per acre was slightly higher than for the 40 and 42-inch rows, as shown in Table 3. These data emphasize the desirability of stands thick enough to take advantage of high fertility and adequate moisture, yet thin enough to avoid yield reductions in dry years. On these Blackland clay soils, practically no fertilizer responses were obtained with spacings wider than 24 inches in 36-inch rows or with less than 7,260 plants per acre.

TABLE 3. PLANT POPULATION PER ACRE FROM VARIOUS ROW WIDTHS AND SPACINGS IN THE ROW

Distance between rows, inches	Plants per acre					
	Spacing in the row, inches					
	12	15	18	24	30	36
36	14,520	11,616	9,680	7,260	5,808	4,840
38	13,755	11,000	9,170	6,678	5,500	4,585
40	13,068	10,405	8,712	6,534	5,202	4,356
42	12,446	9,957	8,297	6,223	4,976	4,148

From these results, plant spacings of about 24 inches in the row (6,500 to 7,000 plants per acre) are recommended for the light sandy soils and other soils with only medium to low fertility. On highly fertile sandy or sandy loam soils in the East Texas Timber Country, the spacing may be reduced to 18 inches, or even less in exceptional cases. On the other hand, 18 inches in the row (8,500 to 9,500 plants per acre) is recommended for the heavier soils with fairly high fertility. Bottom and some upland soils may produce maximum yields with even thicker spacings if a high level of fertility is maintained and water conservation measures are practiced. Thinner spacings will be necessary in the western part of the corn-growing region under dry-land farming conditions where moisture is more of a limiting factor.

Thicker spacings will also affect such factors as ear size, number of ears per plant, weed control and possibly the amount of evaporation from the soil. Although the ear size will be reduced by the use of thicker spacings, it is the number of ears and not the size alone that determines the yield. Ear weights and yields from a spacing-fertility study conducted at the Blackland station near Temple in 1950 show that maximum yields were obtained with an ear weight of one-half pound. Yields decreased with larger ears, indicating that the stand of corn was not adequate for the moisture and fertility conditions. Yields were slightly reduced when ear sizes were less than one-half pound, indicating that stands were too thick for the available moisture and fertility. These results were obtained with Texas 28 and are given in Progress Report 1388. If Texas hybrids are planted, ear size may be used as a reasonable criterion for determining the proper spacing for a particular fertility level.

All of the Texas hybrids developed to date have a tendency to produce more than one ear per plant if fertility and moisture conditions are favorable and wide spacings are used. Ear and stalk counts made in the spacing-fertility experiment at the Blackland station in 1949 and 1950 show that the percentage of plants having more than one ear is reduced by thicker spacings. Texas 20 was used in 1949 and Texas 28 in 1950. The following percentages of plants having more than one ear per plant were obtained: 6 percent from the 18-inch spacing, 13 percent from the 24-inch spacing and 27 percent from the 30-inch spacing. Plants from the 12-inch spacing averaged slightly less than one ear per plant. Weights of these second ears ranged from about .1 to .3 pound, while first-ear weights ranged from about .4 to .6 pound. Since a higher percentage of the ears from the 18 and 24-inch spacings were of uniform size, mechanical harvesting probably would be more efficient for these spacings than for the wider spacings.

The increased number of plants per acre resulting from thicker spacings should make weed control easier, since competition for nutrients would be stronger and the denser shade would not permit vigorous growth of weeds. It should be easier to control certain species of annual, warm-season weeds by the use of uniform thick stands. Since soil moisture evaporation is largely determined by the temperature, the increased shading from thicker stands will probably decrease this loss of soil moisture at a time when it is greatly needed by the corn plants.

Fertilizers

Fertilizer recommendations vary widely for the different soil areas (Figure 4) of the State, depending on moisture conditions, cropping systems and soil types. Since organic matter plays such an important role in both the moisture and fertility within the soil, fertilizer applications should supplement the soil-building rotations, instead of serving as the only fertility practice. Because of the large amount of nutrients required by the corn plant in a relatively short growing season, it is often necessary to make applications of certain nutrients or combinations of nutrients even though a soil-building system is practiced. Estimates of the amounts of nutrients used by the corn crop are useful in discussing fertility problems and practices. The kinds and amounts of raw materials used by an acre of corn plants producing at the rate of 100 bushels per acre are shown in Table 4. The amounts of mineral nutrients actually removed by the harvested crop are somewhat less than those shown in this table, but the requirements of the entire growing plant must be supplied if maximum yields of corn are to be obtained. Fertilizer requirements for a particular area may vary over a period of years. This is especially true if the level of a particular nutrient, such as nitrogen, is kept high for several years. In such instances, the supply of some other nutrient, such as phosphorus or potassium, may become low and actually limit production. Deficiency symptoms of the plant and soil tests are important aids in determining the fertilizer needs, and both should be given more attention.

TABLE 4. KINDS AND AMOUNTS OF RAW MATERIALS USED IN PRODUCING A 100-BUSHEL CROP OF CORN ON AN ACRE

Substance	Pounds per acre	Approximate equivalent
Oxygen	6,800	Air is about 20% oxygen
Carbon	5,200	Carbon contained in 4 tons of coal
Nitrogen	160	500 lbs. of 32% nitrogen fertilizer
Phosphorus	40	450 lbs. of 20% superphosphate
Potassium	125	250 lbs. of 50% muriate of potash
Sulfur	75	75 lbs. of sulfur
Calcium	50	150 lbs. of limestone
Magnesium	50	250 lbs. of magnesium sulfate
Iron	2	10 lbs. of iron sulfate

Fertilizer materials should be applied at the proper time and by the best-known methods for the particular area to provide nutrients readily available to the plant during the growing season. General recommendations regarding fertilizer placement are especially applicable to corn. For best results, the fertilizer should be put in the soil and not spread on the surface. Mixed fertilizers should not touch the seed but should be placed in a band two or three inches on one or both sides of the seed and two or three inches below it. Most of the soils in East Texas are rather sandy and considerable leaching occurs. If heavy fertilizer applications are made here, the best results are usually obtained by applying only a part of the fertilizer at planting time and the remainder as a side-dressing when the corn plants are about two feet high. On the heavy clay soils of the Blackland, Grand and Gulf Coast Prairies, where leaching is negligible, all of the fertilizer may be applied before or at planting time. Application of fertilizers in bands is of particular importance on the heavy, calcareous clay soils, since this practice reduces the amount of applied phosphorus that is quickly fixed by soil particles.

East Texas Timber Country

High yields of corn are possible in the East Texas Timber Country through the use of rather heavy fertilizer applications. Results from Kirbyville in 1950, given in Progress Report 1307, show that the most profitable yield, about 75 bushels per acre, was obtained by the application of 120 pounds of nitrogen, 60 pounds of phosphoric acid and 30 pounds of potash per acre. These amounts should be applied by making an application of a complete or starter fertilizer at planting time, followed by a side-dressing of nitrogen. In Brazos County, on Crockett fine sandy loam, fertilizer applications to corn following corn, as given in Progress Report 1339, resulted in profitable yields in 1950. The best treatment in this test, which yielded 68 bushels per acre, resulted from the application of 90 pounds of nitrogen, 30 pounds of phosphoric acid and 30 pounds of potash per acre. These results, as well as others from the East Texas area, indicate that applications of from 300 to 600 pounds per acre of a complete or starter fertilizer at planting time, followed by a side-dressing of 60 to 90 pounds of nitrogen, are required to produce high yields of corn where corn follows some nonlegume crop. The side-dressing with nitrogen ordinarily will not be necessary where corn follows a good growth of a well-fertilized legume crop.

Nitrogen was the only fertilizer component that gave increased yields of corn on bottom-land soils of the Brazos River near College Station during 1949-50, as shown in Progress Report 1339. With limited moisture in 1949, maximum yields of about 44 bushels per acre were obtained with 60 pounds of nitrogen when corn followed corn. In 1950, when moisture was not a seriously limiting factor, 120 pounds of nitrogen produced maximum yields of about 87 bushels per acre, while only 30 pounds of nitrogen were required to produce maximum yields where corn followed alfalfa. Although no responses were obtained from applications of either phosphoric acid or potash in these tests, repeated heavy applications of nitrogen alone to corn might eventually result in the depletion of these nutrients.

Blackland and Grand Prairies

Consistent increases in corn yields as a result of fertilizer applications have not been obtained in the Blackland and Grand Prairies. Favorable responses from applications of nitrogen usually are obtained in years having a favorable rainfall distribution during the latter part of the growing season. The northeast portion of the Blackland Prairie receives a few more inches of rainfall than the remainder of the region and distribution in June and July is also more favorable. Results at the U. S. Cotton Field Station at Greenville show fairly consistent yield increases from applications of 40 to 60 pounds of nitrogen per acre. Recent fertility tests conducted at the Temple and Denton stations, which are summarized in Progress Reports 1388 and 1360, respectively, show that the lack of available phosphoric acid is one of the limiting factors in corn production on Blackland and Grand Prairie soils. Consistent and economic responses were obtained from applications of 40 pounds of phosphoric acid per acre to corn on Austin clay at the Temple station in 1948-50. Even larger increases were obtained by the Denton station from the use of 60 pounds per acre of phosphoric acid alone or in combinations with nitrogen. These tests were conducted on San Saba clay and Denton stony clay, each following a non-legume. To obtain maximum yields in the Blackland and Grand Prairies, spacings of 18 to 24 inches between plants in the row must be used. With these spacings, applications of both nitrogen and phosphoric acid probably will give economic yield increases in most years. From the data available, the most profitable yields should be obtained from applications of 30 to 60 pounds per acre of both nitrogen and phosphoric acid. Corn following good crops of phosphated legumes probably will fail to give economic responses to fertilizer applications, except in years having a favorable amount and distribution of rainfall.

Gulf Coast Prairie

Fertilizer practices in the Gulf Coast Prairie vary considerably for the different soil groups. On the black clay soils, applications of 60 to 80 pounds of nitrogen and 40 pounds of phosphoric acid per acre are recommended where corn follows a non-legume crop. If the corn follows a fertilized legume crop, the nitrogen application may be decreased by 40 to 50 pounds per acre, depending on the growth of the legume crop. The sandy loam soils of the area require some potash in addition to phosphoric acid and a heavier application of nitrogen. Applications of 80 to 90 pounds of nitrogen, 30 to 40 pounds of phosphoric acid and 20 pounds of potash per acre should produce good yields of corn. Because of the poor drainage of the Gulf Coast Prairie, part of the fertilizer applications should be made at the time of planting so that seedling vigor will be increased and better stands will be obtained.

West Cross Timbers

The sandy soils of the West Cross Timbers usually are low in fertility and require fertilizer applications to produce maximum yields. Although rainfall is somewhat limited for high corn yields, the recommended fertilizers include applications of 30 to 40 pounds of nitrogen, 20 to 30 pounds of phosphoric acid and about 15 pounds of potash per acre. If corn follows a fertilized legume crop, the nitrogen application may be limited to that applied in the complete fertilizer at the time of planting.

Rio Grande Plain

Soils of the Rio Grande Plain range from light sand to rather dark clay. The amount and distribution of rainfall are highly variable and fertilizers do not show responses in some years. A side-dressing of about 30 pounds per acre of nitrogen is recommended for the black clay soils of the area. On the sandy loam soils, an application of about 10 pounds of nitrogen and 20 pounds of phosphoric acid at planting time is recommended, followed by a side-dressing of 30 pounds of nitrogen per acre. In the Lower Rio Grande Valley, very high corn yields are obtained with proper fertility practices, thick spacing and irrigation. Fertilizer recommendations for corn grown on irrigated lands include 40 to 80 pounds of nitrogen and 80 to 120 pounds of phosphoric acid per acre applied at planting time, followed by a side-dressing of about 60 pounds of nitrogen per acre. Following a good growth of phosphated legumes that have been turned under, the nitrogen application may be reduced by 40 or 50 pounds per acre.

Rolling and High Plains

Corn production under dry-land farming conditions on the Rolling and High Plains is hazardous because of the low rainfall received. Applications of 40 to 50 pounds of nitrogen and 50 to 60 pounds of phosphoric acid per acre are recommended for corn on the light sandy soils of the Rolling Plains. With irrigated land, primarily on the High Plains, applications of 30 to 60 pounds of nitrogen per acre generally are recommended.

Soil-building Crops

The purpose of fertility practices is to supply adequate amounts of available nutrients at the proper time in the growing season to take full advantage of the moisture received during the crop year. Since the availability of plant nutrients depends partly on the available moisture in the soil, improvements in the water relationships within the soil are of utmost importance if favorable corn yields are to be obtained consistently from year to year. The importance of soil organic matter should not be overlooked in any discussion of fertility practices for the corn-growing areas of Texas. Some of the functions of organic matter in the soil are: to increase the rate of penetration and water-holding capacity of the soil and thus reduce runoff; to release essential plant nutrients such as nitrogen; to make more available the mineral constituents of the soil; and to make the soil mellow and easier to cultivate. Because organic matter affects most of the important factors determining soil productivity, long-time fertility programs should include cropping systems that provide sources of organic matter. These sources will include crop residues, green manure crops, deep-rooted grasses and legumes, and barnyard manure.

Fertilized adapted legume and grass crops in our cropping systems will solve a large portion of the fertility and soil conservation problems. Fertilizers such as phosphoric acid and potash enable the legume crops to produce large yields of green material to be used for hay, grazing or green manure crops. Management of the various crops is an individual matter and only a few of the more general cropping systems will be mentioned.

Vetch fertilized with both phosphoric acid and potash at the time of seeding in the fall has proved beneficial as a soil-building crop on the sandy soils of the East Texas Timber Country and the West Cross Timbers. Results given in Texas Bulletin 731 from College Station, Nacogdoches and Tyler, from 1937 to 1947, show that fertilized vetch produced average yields of green matter per acre of from 10,000 pounds at Nacogdoches to as high as 19,000 pounds at Tyler. These yields were obtained from fall-planted vetch that was turned under the following spring. The average yield of 12,000 pounds of green matter produced at College Station contained about 100 pounds of nitrogen. Yields of cotton following the fertilized vetch varied from 39 percent higher than the untreated plot at College Station to 75 and 84 percent at Nacogdoches and Tyler, respectively. The residual effects of the vetch crops were measured by yields of corn which followed the cotton. At College Station, the residual effect of the vetch resulted in about a 40 percent increase in yield over the untreated plots; at Tyler, the increase was about 95 percent. These results were obtained by using the vetch as a winter green manure crop in a continuous row-crop system which does not provide much protection from soil erosion. Rotations in which the fertilized vetch is grazed or allowed to make seed, as is the common practice in the West Cross Timbers and in parts of East Texas, would give more protection from erosion and also would increase the fertility of the soil. Other annual winter green manure crops include Singletary peas, Dixie Wonder peas and Austrian winter peas. Crotalaria is sometimes used as a summer legume for soil-building purposes.

The annual lespedezas are outstanding in their ability to conserve and build up the soil and, at the same time, yield income from hay, grazing or seed. These deep-rooted crops offer excellent possibilities for use in the sandy soils of East Texas. The annual lespedezas may be used in short rotations such as a year or two of row crops, followed by a year or two of annual lespedeza alone or in mixtures for hay or grazing. Exceptionally high yields have been reported from northeast Texas when corn followed 2 to 3 years of lespedeza for hay. In fact, yields in the neighborhood of 150 bushels per acre have been obtained in several instances in yield contests sponsored by the Texas Agricultural Extension Service.

Soil-building crops for the calcareous clay soils of the Blackland and Grand Prairies center around the sweetclovers. Either the annual type, such as Hubam and *Melilotus indica*, or the biennial types, such as Madrid and Evergreen, may be used, depending on the type of farming system practiced. The deep-rooted biennials are especially desirable in forage-grain-livestock types of farming as they provide longer periods of grazing. For optimum growth of the sweetclover, about 40 pounds of phosphoric acid per acre should be applied at seeding. Time of seeding varies from early fall to early spring, depending on the rotation and the variety of clover to be planted.

The sweetclovers offer several possibilities from the standpoint of utilization other than as green manure crops. They can be used for grazing, for hay or for a seed crop, and at the same time improve the chemical and physical properties of the soil. They also are well adapted for interplanting with or overseeding on small grain crops. Some of the most promising possibilities involve the use of small grain-sweetclover mixtures in various cropping systems. Four-year averages from a study at Temple on Austin clay, as given in Progress Report 868, show that corn following cotton produced 34.9 bushels per acre while corn following Hubam sweetclover for hay produced 38.8 bushels per acre. Unpublished data from the Blackland station show that corn following cotton on deep Houston black clay produced 50.5 bushels for the period 1949-51, while corn following a mixture of oats and sweetclover produced 54.4 bushels. Oat yields from the mixtures were equal to those from oats alone following corn. Unpublished results from studies of legumes for soil improvement at the Denton station in 1950 and 1951 show that corn following non-legumes produced 33.6 bushels per acre, while corn following the sweetclovers produced 43.7 bushels. In this study, the beneficial effects from the clover crops grown for seed were just as great as when the clover was plowed under for green manure. From the results obtained at the Temple and Denton stations, it is apparent that the use of sweetclovers in cropping and grazing systems in the Blackland and Grand Prairies will result in increased corn yields.

Shallow-rooted legumes that are often used as winter green manure crops in the Blackland and Grand Prairies include Austrian winter peas, Dixie Wonder peas, Singletary peas and vetch. These crops are especially well adapted for use as winter green manure crops in continuous row-crop systems, but there are several precautions that should be observed if corn is to follow these legumes. If these crops are allowed to make much growth in late winter, seedbed preparation and planting will be delayed. Poor germination also may result from planting corn soon after the green manure crop has been plowed under. The use of vetch is confined largely to the sandy loam and clay loam soils of the Wilson and Crockett series on the north and eastern edge of the Blackland Prairie. The planting of vetch for seed production has increased considerably in the last few years on these soils.

The sweetclovers are also the primary soil-building crops for the Gulf Coast Prairie, Rio Grande Plain and the Lower Rio Grande Valley. On the heavy calcareous clay soils of the

Rio Grande Plain, Hubam sweetclover is fall-planted and may be used as a winter green manure crop, as a summer legume in pure stands or in a mixed planting with small grain crops. Utilization of sweetclover depends on the type of farming or cropping system, as discussed for the Blackland Prairie and Grand Prairies. *Melilotus indica* matures sooner than Hubam and is quite tolerant of sandy and acid soils of the areas. Its ability to mature quickly enables it to fit well in rotations requiring soil-building crops that can be turned under early.

Soil-building crops are not used extensively in either the Rolling or High Plains because of the low rainfall. Alfalfa, hairy vetch and the sweetclovers may be recommended for these areas, however, when soil-improving legumes are planted.

Conservation and Use of Water

The supply of available moisture is one of the most acute problems confronting corn producers in Texas, and additional emphasis should be given to finding solutions to this problem. Most of the corn in Texas is grown during the 5-month period from March 1 to July 31. The average rainfall received during this period, as shown in Table 12, varies from about 18 to 20 inches in the East Texas Timber Country, Gulf Coast Prairie and the northeast portion of the Blackland Prairie, to about 14 or 15 inches in the Rio Grande Plain and West Cross Timbers. These amounts, plus an additional four or five inches of water estimated as being normally held in the top three feet of the soil, give an average total of 18 to 25 inches that may be available to the crop. Since the rainfall is below normal about half the time, the potential supply often is less than the amounts shown. The important problem, in both normal and sub-normal years, is to hold the moisture that is received in the late fall and winter, as well as that received during the growing season, for use by the corn crop.

Two of the most important factors in water conservation are the intake capacity and the water-holding power of the soil. Maintaining a deep soil profile by preventing erosion and improving the physical properties of the soil through the use of deep-rooted legumes and grasses in cropping systems will help increase the net supply of available water.

Much higher yields may be obtained in the future if methods are put into practice which will conserve a large part of the rainfall received. Calculations using the consumptive-use formula, as presented by Blaney and Criddle in Soil Conservation Service Technical Publications 96, show that about 23 to 24 acre-inches of water are required for high

TABLE 5. FACTORS AND PRACTICES WHICH AFFECT THE SUPPLY AND EFFICIENT USE OF SOIL MOISTURE[1]

Factors affecting the soil water supply	Practices found helpful in the conservation and economical use of the soil water supply					
Preventing rainfall run-off	Increase organic matter	Increasing depth of root zone	Good stand, vegetable cover	Terracing	Contour tillage	Ridged
Increasing capacity and water-retaining power	Increase organic matter	Improve structure	Loosen root zone when compact	Increase vegetation		
Curtailing evaporation	Straw-litter mulch	Manure-mulch	Minimum cultivation	Good stand, shade	Weed control	
Decreasing transpiration ratio	Select good land over poor land	Barnyard manure	Liberal chemical fertilizer	Select varieties		
Increasing condensation	Good stand, shade	Litter-mulch	Vegetative mulch	Increase organic matter		
Using water more	Time of planting	Select varieties				
Artificial application	Irrigation					

[1]Adapted from Better Crops and Plant Food. 33(5): 9-14. 1949.

corn production in Central Texas. These calculations are based on temperature, hours of daylight and adequate moisture in the root zone for the 4-month growing season from April 1 through July 31. By the use of conservation measures, the East Texas Timber Country, Gulf Coast Prairie and most of the Blackland Prairie should have a sufficient supply of moisture during most of the growing season to meet the requirements of the corn crop without any serious limitation of yields.

The efficient use of water by plants should be closely related to the actual conservation of water, if high yields are to be produced. Factors influencing water use listed by Blaney and Criddle, which cannot be altered or controlled by the corn producer, include humidity, wind movement and latitude. Other factors listed include temperature, growing season, soil fertility and insect and disease pests, all of which may be altered or controlled by the farm operator. The rate of consumptive use of water by the plant is probably affected more by solar energy than by any other factor. Although temperature cannot be completely controlled by man, early planting permits the corn crop to mature early and escape some of the extremely high temperatures of July and August. Thick spacings provide dense shade, thereby reducing sunlight and heat energy and resulting in a decrease of both evaporation and transpiration from the shaded soil and leaves. If the fertility of the soil is improved by applying fertilizers or barnyard manure, or by plowing under legume crops, both yields per acre and consumption of water by plants may be expected to increase. An increase in the fertility of the soil, however, can be expected to decrease the amount of water consumed per unit of crop yield. All factors which contribute to high yields per acre, therefore, are helpful in obtaining greater efficiency from limited supplies of water.

Some practices which should help in the conservation and efficient use of soil moisture for crop production are shown in Table 5. The importance of preserving and increasing the organic matter content of the soil should be stressed, since this affects the supply of water and its efficient use by the crop. Practices, such as the use of thick stands and adapted hybrids, early seedbed preparation, and the use of legumes and fertilizers, are controlled by the farmer and should be strongly emphasized. It is apparent that the efficient use of water received as rainfall will result from a combination of all practices that increase the acre yields of corn as well as those that serve only as more direct water conservation measures.

Sizes of Planting Seed

Seed parents of the earlier hybrids, particularly Texas 12 and Texas 20, produced rather small seed. Although these hybrids performed satisfactorily and the seed was of a good quality, most Texas farmers prefer larger seed for planting. They are accustomed to selecting seed corn with large grain and harvesting the same type as had been planted. In hybrid seed corn production, the seed represents only half of the parentage, and the effect of the pollen parent on grain size cannot be determined until the succeeding crop is harvested. Thus, in certain hybrids, the size of the planting seed is not a good indication of the size of the grain that will be harvested. Because of farmer preference for large kernels, there has been a tendency in developing the later Texas hybrids to use seed parents which produce medium to large seed and pollen parents that produce fairly large kernels. In processing the seed of any hybrid, the seed producer separates the shelled corn into various grades or sizes, and usually offers the round grades and sometimes the medium flats at reduced prices. The seeds graded as medium flat short and the smaller grades usually are sold as feed corn.

Because of farmer discrimination against small-seeded types, tests involving Texas 18 and 20 were conducted at both College Station and Temple in 1948 to compare the emergences and yields from plantings of the different seed grades. The number of seed per pound and the number of acres that could be planted per bushel were calculated from seed counts and weights of the various grades. The results are shown in Table 6. The emergence percentages and yields of the different seed grades are shown in Table 7.

TABLE 6. NUMBER OF SEED PER POUND AND ACRES PLANTED PER BUSHEL FOR DIFFERENT SEED GRADES

Seed Grade	Seed per pound		Acres per bushel[1]	
	Texas 18	Texas 20	Texas 18	Texas 20
Thick large flat	1,110	1,310	7.1	8.4
Large flat long	1,160	1,400	7.5	9.0
Medium round	1,510	1,480	9.7	9.5
Medium flat long	1,600	1,680	10.3	10.8
Medium flat short	1,940	2,090	12.5	13.4

[1]The number of acres that can be planted per bushel of seed by planting the seed 18 inches apart in 40-inch rows.

No significant differences were obtained in the average percentage emergence from plantings of the various seed grades at College Station or Temple. Yields of corn from the various seed grades showed no significant differences at College Station, but there were significant differences in the

TABLE 7. EMERGENCE PERCENTAGES AND YIELDS OF DIFFERENT SEED GRADES

Seed grade	Emergence 21 days after planting			Yield of shelled corn per acre, bushels		
	Texas 18	Texas 20	Average	Texas 18	Texas 20	Average[1]
			College Station			
Thick large flat	94.2	95.0	94.6	58.4	53.2	55.8
Large flat long	87.6	97.2	92.9	56.4	55.9	56.2
Medium round	94.0	94.0	94.0	58.0	57.8	57.9
Medium flat long	93.0	95.5	94.2	54.3	52.4	53.4
Medium flat short	90.4	91.8	91.1	64.4	55.0	59.7
Average	91.8	94.7	93.3	58.3	54.9	56.6
			Temple			
Thick large flat	94.2	97.5	95.8	32.0	30.9	31.4
Large flat long	95.5	98.7	97.1	26.5	24.5	25.5
Medium round	98.0	97.7	97.8	27.9	21.2	24.6
Medium flat long	96.5	97.0	96.2	27.4	30.8	29.1
Medium flat short	98.0	97.0	97.5	20.4	24.3	22.4
Average	96.4	97.6	97.0	26.8	26.3	26.6

[1]The difference in yield between any two averages from the Temple test must equal or exceed 7.0 bushels to give odds of 19 to 1 that such a difference is real and not due to chance.

yields at Temple. The moisture supply during the latter part of the growing season was extremely low at Temple and the seedlings from the small seeds may have lacked vigor, thus causing a slight delay in maturity of the plants. This delay probably accounts for the reduced yields obtained from the smaller seed in the Temple test.

These results indicate that some of the smaller grades of good quality seed may be used with assurance of obtaining satisfactory stands and yields. They also emphasize the desirability of using seed grades large enough to give good emergence and seedling vigor. The number of acres that can be planted per bushel of seed of the various grades, as given in Table 6, shows the advantage of using the small seed. Ordinarily, all flat grades are sold at about the same price, but the round grades usually are priced at only 60 to 70 percent of the price of the flat grades. Thus, good quality seed of the medium grades, and especially of the round grades, offer a good opportunity to reduce the costs of seed corn per acre.

Topping

Topping of corn refers to the practice of cutting the top portion of the corn plant above the ear for use as dry forage. Although the practice may not be as common now as it has been, many farmers continue to use corn tops as forage. Early studies by the Texas Agricultural Experiment Station showed that grain yields were reduced if the tops were cut within 15 days after silking. Tests were conducted in 1948-50 at College Station and Temple to determine the effect of topping some of the Texas hybrids at several dates after silking. Texas 11W was used at College Station each year, while at Temple Texas 20 was used in 1948 and 1949 and Texas 28 in 1950. Results are shown in Table 8. Topping only 14 days after silking resulted in significant yield reductions at both locations, while topping 28 days after silking resulted in only slight reductions in yield. The percentage decrease in yield for all dates of topping was similar at both locations for the 3-year period.

CORN DISEASES

Part of the Texas corn crop is destroyed each year by diseases. The damage varies considerably from year to year, depending primarily on weather conditions during the growing season. The most common disease-producing organisms are rather widespread wherever corn is grown, and they may be expected to cause appreciable damage whenever conditions favor their development. Most of the diseases develop best during seasons of abundant moisture. No particular disease ordinarily causes such severe damage, for example, as the rusts of small grain; therefore, diseases often go unnoticed or do not receive adequate attention.

Corn disease organisms may bring about reduction in yields by inciting leaf blight, ear rot or stalk rot. Several soil-borne organisms enter the stalk through the roots and cause damping off, stalk rot and ultimately ear rot. Air-borne organisms frequently enter the ear and lower the grain quality by damaging the kernels. The stalk rots, in addition to causing a direct reduction in yields, may also have a more serious effect by weakening the stalks and causing breakage. Since any degree of stalk breakage results in a loss of ears at harvest, as well as a greater harvesting cost, severe damage of this nature represents one of the most acute corn disease problems in Texas.

The use of resistant hybrids is one of the most successful means of reducing damage from corn diseases. Only limited attention has been given in Texas to the development of resistant hybrids, although some improvement has been effected through the selection of standing plants and disease-free ears. These efforts are being expanded, and experimental material in the breeding program is now being tested for resistance to several of the more important diseases. The success of such programs in other states indicates that it should be possible within a few years to develop more disease-resistant hybrids for Texas conditions.

Proper soil management and balanced fertility are important factors in controlling certain corn diseases. The maintenance of adequate organic matter through recommend-

TABLE 8. RESULTS FROM CORN TOPPING TESTS CONDUCTED AT COLLEGE STATION AND TEMPLE, 1948-50

Days after silking	Yield of shelled corn per acre, bushels				Percent decrease below check
	1948	1949	1950	Ave.[1]	
		College Station			
Not topped	58.8	69.1	77.0	68.3	
14	51.3	58.3	64.6	58.1	14.9
28	53.9	67.1	72.0	64.3	5.9
42	63.7	66.9	72.9	67.8	
		Temple			
Not topped	25.8	63.5	57.6	49.0	
14	20.6	61.1	41.9	41.2	15.9
28	26.4	63.1	49.8	46.4	5.9
42	29.5	65.6	54.2	49.8	

[1]The difference in yield between any two averages from the College Station test must equal or exceed 6.5 bushels, and from the Temple test 3.3 bushels, to give odds of 19 to 1 that such differences are real and not due to chance.

ed cropping systems and the use of fertilizers when needed are essential practices. A combination of optimum physical tilth and adequate plant nutrients results in the production of healthy, vigorous plants which are better able to withstand attacks by disease organisms.

General descriptions of the more important corn diseases and causal agents, and control measures recommended, are given in this bulletin as a service to the corn growers of Texas.

Seedling Blight

Considerable damage occurs from seedling blight when cold, wet weather follows planting. Several seed-borne organisms, *Fusarium moniliforme* Sheld., *Giberella zeae* (Schw.) Petch, *Diplodia zeae* (Schw.) Lev., *Diplodia macrospora* Earle, *Diplodia frumentii* E. & E., *Aspergillus* spp. and *Penicillium* spp., cause damage in the seedling stage. Attacked seedlings may actually be destroyed before the sprouts emerge, or may be killed soon after emergence. Plants subjected to seedling disease usually produce weak, stunted plants with reduced yields. Seedling blight may be effectively controlled by planting sound, well-matured seed which have been treated with a recommended fungicidal dust or slurry. Practically all hybrid seed corn is now treated with protective materials and considerable care is exercised in processing to prevent damage to the seed. In addition to the use of good seed, corn planting should be delayed until the soil has warmed up and the danger of cold weather is largely past.

Stalk Rots

Stalk rots are probably the most serious diseases that attack corn in Texas. Several organisms are capable of attacking the stalks, but all have the same general effect of reducing yields and increasing susceptibility to stalk breakage. Severe field infections frequently result in a majority of plants being broken by the time of harvest. In most instances, considerable progress is possible in the development of hybrids resistant to the various stalk-rot organisms. Complete plowing under of all crop residues and adequate supplies of both potash and nitrogen are important in reducing the effects of these various organisms.

Charcoal rot, *Sclerotium bataticola* Taub., is prevalent in all corn-growing areas of Texas and is most severe under dry conditions. It is a cortical and internal stalk rot of corn, sorghums and many other crops. The most conspicuous symptoms appear as the plants reach maturity. The outer part of the stalk darkens and the pith shreds, with only the vascular bundles remaining intact. The whole inner portion of the stalk turns black, or charcoal-like, as a result of the numerous, tiny black fungus bodies. This disease attacks the plants late in the growing season and frequently causes stalk breakage.

Brown spot or Physoderma disease, *Physoderma zea-maydis* Shaw, causes the greatest damage in Southeast Texas under hot, humid conditions. The infection first appears as small, circular, reddish-brown spots on leaf and sheath tissue. The small spots enlarge to form brown blotches of tissue filled with dusty brown spores. Sheath infections spread into the stalks and concentrate in the nodal areas, and cause stalk breakage.

Diplodia stalk rot, *Diplodia zeae* (Schw.) Lev., is the most severe stalk-rot organism in the Corn Belt. It extends into Texas and causes considerable damage in North-central and Northeast Texas. It is first apparent through premature dying of infected plants. Such plants show a brownish discoloration at the base of the stalk; the pith is gradually destroyed, leaving only the vascular bundles. Severe early infections result in chaffy ears and a high degree of stalk breakage by harvest.

Fusarium stalk rot, *Fusarium moniliforme* Sheld., is prevalent in South and East Texas. Infections are commonly associated with the roots and lower nodes of the stalk. The disease causes rotting of the pith, premature ripening and stalk breaking. The internal portions of the stalk turn tan or light pink.

Ear Rots

Numerous organisms responsible for damage to the ears cause a considerable reduction in yield and quality of grain. Various degrees of injury are inflicted on the ear by such organisms, depending primarily on the mode of entry of the parasite into the ear. The ear rots are particularly severe in East Texas and along the Gulf Coast where high temperatures and humidities usually prevail during the period of grain development. Ear rots also cause appreciable damage in any of the corn-growing regions during seasons of excessive rainfall. Certain hybrids exhibit some degree of resistance to the ear-rot organisms, and considerable progress should be possible in the development of resistant hybrids for the more humid areas. Good shuck covering and pendant ears are characteristics which reduce injury from the various ear-rot organisms.

Pink kernel rot, *Fusarium moniliforme* Sheld., first appears as a pink coloration on individual kernels. As the disease progresses, the infected kernels become powdery pink. The disease organism infects individual or isolated groups of kernels by entering down the silks. Punctures in the shucks as a result of earworm attacks also provide an easy means of entry.

Diplodia ear rot, which is caused by *Diplodia zeae* (Schw.) Lev., *D. macrospora* Earle or *D. frumentii* E. & E., may infect either through the tip or butt of the ear; however, the organism ordinarily enters through the shank from a diseased stalk and progresses upward from the base of the ear. The entire ear in some cases is infected. The rots caused by *D. zeae* and *D. macrospora* are characterized by a dense white growth of the fungus on and between the kernels and a dull brown discoloration of the rotted kernels. *D. frumentii* causes a purplish discoloration of the kernels that is a result of the development of fungus fruiting-bodies under the seed coat.

The blue, green and black ear rots are caused by a number of the ever-present air-borne fungi such as *Aspergillus* Spp., *Penicillium* spp. *Cephalosporium* spp., *Rhizopus* spp. and *Mucor* spp. These organisms cause varying damage, although losses are more severe during wet seasons. This type of damage affects the yield, but more especially it lowers the quality of the grain. The mold damage is generally superficial and slight rotting of the grain occurs. Infection enters through the tips of the ears, and loose, open-shucked hybrids are particularly susceptible. Damage of this type in seed corn is reduced by early harvesting and artificial drying.

Leaf Diseases

Leaf-disease organisms cause an appreciable reduction in yield during hot, humid seasons. In most seasons, however, they are of little importance, except in Southeast Texas. All of the Texas hybrids show some degree of susceptibility to these diseases, and efforts are being made to develop resistant hybrids. Some progress in this direction is indicated by the behavior of the newer experimental hybrids.

Brown spot or Physoderma disease, *Physoderma zea-maydis* Shaw, is characterized by small, circular, reddish-brown spots on the leaf blades and sheaths. Initial infections occur frequently during the early part of the growing season when the spores are lodged in the leaf whorls, but later development is usually retarded as a result of dry weather.

Southern leaf blight, *Helminthosporium maydis* Nishik and Miy., appears as small oblong to elongate lesions between veins of the leaves. These lesions are commonly buff to reddish-brown. Early infection results in damage to a considerable leaf area and subsequent reduction in yield. As with the other leaf blights, this disease is more severe during periods of high moisture. Attacks occur frequently during the latter part of the growing season but cause only slight damage.

Northern leaf blight, *Helminthosporium turcium* Pass., in contrast to the other leaf diseases, is more prevalent in North Texas. The disease symptoms consist of long, elliptical, tan to gray-green spots, which are scattered over the leaves. In a severe infection, as is also true with *H. maydis,* most of the leaf surface becomes covered with these lesions.

Corn rust, *Puccinia sorghi* Schw., occurs to a limited extent each year. The symptoms appear as small, brownish, pustular spots on the leaves. It may be very severe on susceptible plants, but the attacks are usually too late in the growing season to cause any appreciable damage.

Several leaf diseases of limited importance which occur in Texas are bacterial wilt, *Bacterium stewartii* E. F. Sm.; bacterial leaf blight, *Pseudomonas alboprecipitans* Rosen; and Helminthosporium leaf spot, *Helminthosporium carbonum* Ullstrup.

Smut

Smut is one of the most conspicuous diseases of corn and is easily recognized by the prominent galls or knobs of black, powdery spores. The causal agent is the fungus, *Ustilago maydis* (DC.) Cda., which overwinters as spores in old smut galls or in the soil. Losses from smut vary with seasonal conditions and ordinarily are more severe in dry years. One of the best methods of control is to maintain a uniform growth of corn by the use of proper fertility practices. Certain inbred lines show some degree of resistance, which indicates that the development of hybrids with smut resistance offers some promise.

CORN INSECTS

Insects cause considerable damage each year to the Texas corn crop. Some of these pests attack the plants, while others damage the ears and grain directly. Poor stands, reduced yields or lowered grain quality are possible consequences of attacks by the various types of insects. Proper cultural practices, the use of insecticides and the development of resistant hybrids offer possibilities in combating injury by insects. Highly resistant hybrids, when obtainable, offer the most effective and economical means of control. Considerable effort in the corn breeding program is being directed toward the development of hybrids resistant to the more injurious insects.

Soil-infesting Insects

The larvae of several soil-infesting insects frequently cause severe damage to germinating corn. These insects may attack either the germinating seed or young seedlings, and thereby cause a considerable reduction in stand. Severe infestations of particular fields may result in the loss of almost the entire stand. The most serious offender in Texas is the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barb. Others of minor importance are the wireworm, *Agriotes* spp.; false wireworm, *Eleodes opach* (Say); and white grubs, *Phyllophaga* spp.

Injury by stand-destroying insects may be particularly heavy where some cover crop has occupied the land just previous to corn. Such infestations usually are reduced by clean cultivation preceding corn planting. Good fertility practices aid in combating these insects, since vigorous, healthy plants are better able to withstand attacks. Heavy seeding is also a good practice where damage from stand-destroying insects is anticipated. Very little is known about the development of hybrids resistant to such insects, but profusely-rooting hybrids are capable of more effective recovery than those with ordinary rooting habits. Some progress has been made in the use of insecticides to control these insects, but the results are preliminary. Applications of lindane or chlordane in the drill just prior to planting have controlled most soil-infesting insects, but there are practical difficulties in such an operation. Some success has also been obtained by mixing the insecticide with fertilizer and applying the mixture at, or just prior to, planting. Lindane has been used as a control by applying it directly to the seed, but some difficulty has been encountered in obtaining good coverage by this method. It is also essential that the application be made just prior to planting or the seed may be damaged by the treatment.

Insects Attacking Plants

Several insects attack the corn plant at different stages of growth and, depending on the severity of infestation, cause varying reductions in yield. The corn earworm is the most serious of these pests in Texas, although a few others cause some damage in particular seasons or in certain areas.

The corn earworm, *Heliothis armigera* (Hbn), is distributed throughout the Texas corn-growing region and all corn is attacked to some degree. The larvae ordinarily enter through the tip of the ear, feed on grains in that vicinity and leave the ear to pupate by gnawing a hole through the shuck. Considerable grain is destroyed or damaged and easy access to the ear is established for various disease pathogens. Although control has been effected on small acreages with insecticidal oil emulsions containing DDT, this method is not practical for typical farm acreages. A reasonable degree of resistance to the corn earworm has been obtained in the present Texas hybrids, and the more resistant ones—Texas 24 and 30—should be planted where infestations are severe. Some of the newest experimental hybrids are extremely resistant, and their introduction should greatly reduce the amount of earworm damage. Long, thick, tight shucks are the most effective characteristic possessed by these hybrids in minimizing damage from attacks by earworms.

The Southwestern corn borer, *Diatrea grandiosella* Dyar, is one of the most destructive insects that attack corn plants in Texas. Its total effect is not great, however, since its range is restricted almost entirely to West Texas where very little corn is grown. Most corn in the Rolling and High Plains is attacked by this insect, and it acts as a strong deterrent to corn production in both of these areas. Corn borers cause their greatest injury by boring within the stalk or into the shank; this results in lodging and ear dropping, respectively. Since attacks usually occur late in the season, some escape is offered by early planting. There is little indication at present of varietal resistance to the Southwestern corn borer, and more information is needed to determine the feasibility of developing resistant hybrids.

The Southern cornstalk borer, *Diatraea crambidoides* (Grate), also occurs in Texas, but it is not widespread and causes little damage.

The chinch bug, *Blissus leucopterus* (Say), is of very little general importance, although severe infestations occur occasionally and cause rather serious damage. It is more prevalent in North Texas and usually is more serious on late-planted corn. The greatest damage is caused by the adults feeding on the young seedlings, and entire stands may be destroyed in extremely heavy attacks. Damage during late stages of growth results in lodged plants and reduced yields. Since small grain fields provide a possible source of infestation, an important precautionary measure in preventing chinch bug damage to corn is to avoid planting close to maturing grain fields. Some of the organic insecticides have proved effective for the control of this pest. Some resistance to chinch bugs has been noted among Corn Belt hybrids, but there is no indication of resistance in the Texas hybrids.

The corn leaf aphid, *Aphis maidis* Fitch, causes very little damage to corn in Texas. Aphids frequently may be observed attacking individual plants about tasseling time, but infestations are seldom severe, except in occasional late-planted fields or where late-maturing varieties are grown. No especial effort has been made toward the development of aphid-resistant hybrids in Texas, since the infestations are relatively unimportant. Progress in this direction has been made in other states where the problem is more acute.

Grasshoppers, *Melanoplus differentialis* (Thos.), are a threat to corn production in some areas. Practically all leaves may be stripped from the plants in some instances. A practical control usually may be obtained by the early-season treatment of nearby infested areas with insecticides such as toxaphene, chlordane, benzene hexachloride, aldrin and dieldrin. Some differential susceptibility of corn hybrids to grasshoppers has been reported by numerous workers, indicating that breeding for resistance may be possible should the problem be of sufficient importance. Since infestations are infrequent, no information is available on the relative susceptibility of Texas hybrids to grasshoppers.

Insects Attacking Stored Grain

Insects which attack stored grain are responsible for severe losses each year to corn stored either as grain or in the ear. These insects cause rather extensive damage every year in part of the State, and they are particularly injurious in seasons of high rainfall.

The rice weevil, *Sitophilus oryza* (L), in most seasons infests all corn grown in the southern and eastern parts of the Texas corn-growing region; in the more humid seasons it also occurs in the central and western parts. Infestations are much less severe during extremely hot, dry summers and, in exceptional years, practically no weevil populations are found. Infestations ordinarily occur in the field, but very little damage is done by harvest time. The greatest injury occurs in storage, particularly during periods of high temperatures. With severe infestations, much of the grain in storage may be destroyed. Stored-grain injury may be controlled by placing the corn in tight bins and treating it with proper fumigants. Both carbon disulphide and an ethylene dichloride-carbon tetrachloride mixture are effective in controlling weevils. Breeding for resistance to weevils offers some promise, but the present Texas hybrids are susceptible to severe weevil attacks. Considerable effort is being directed toward the development of resistant hybrids for the areas where weevil infestation is serious. As in the case of resistance to earworm, long, thick, tight shucks help prevent weevil infestation.

The angoumois grain moth, *Sitotroga cerealella* (Oliv.), is fairly prevalent throughout the State, causing some damage to corn in storage. Infestation, as in the case of the rice weevil, frequently occurs in the field, but most of the damage is done during storage. With heavy infestations, considerable loss occurs due to feeding of the larvae inside individual kernels. Control measures similar to those used for the rice weevils are applicable to the angoumois grain moth.

HYBRID CORN BREEDING PROCEDURES

The development of adapted corn hybrids for the major corn-growing regions of the United States represents one of the major advances in the field of corn improvement. Before the successful development of hybrid corn breeding procedures, little progress had been made in the improvement of corn varieties beyond that already attained by the American Indians. The success of this method led to the establishment of extensive hybrid breeding programs in all important corn-growing states. Now, more than three-fourths of the corn acreage in the United States is planted to hybrids. This rapid acceptance of corn hybrids provides ample evidence of the ability of adapted hybrids to outyield the best open-pollinated varieties.

The development of hybrid corn is a direct result of genetic studies conducted during the early part of this century by G. H. Shull of the Carnegie Institution and E. M. East of the Connecticut Agricultural Experiment Station. A new method of corn improvement was advanced on the basis of their discovery that increased yields might be obtained by crossing previously inbred lines of corn. It was not until 1919, however, when D. F. Jones of Connecticut suggested the production of double crosses, that their idea became of practical importance. Soon, hybrid corn breeding programs were initiated in several states in an attempt to develop hybrids for particular regions. This program advanced more rapidly in the Corn Belt, and many high-yielding, adapted hybrids were developed. More than 90 percent of the entire Corn Belt acreage is now planted to hybrids. The success of corn hybrids in the North and East soon resulted in the initiation of breeding programs in practically all states where the crop is of any appreciable importance.

Breeding methods devised especially to utilize hybrid vigor have been responsible for the successful development of adapted corn hybrids. To the original concepts presented by East and Shull, numerous workers in recent years have contributed important additional information on methods and procedures. A brief description of such developments is given to provide a general understanding of the overall procedures.

In a technical sense, the term "hybrid" may be applied to any cross-bred plant or animal. Consequently, since corn is a cross-pollinated crop, all corn may be considered as hybrid. A corn plant is naturally wind-pollinated and plants in corn fields are constantly hybridizing with one another. The term "hybrid corn," as now used commercially, however, refers to controlled crosses, usually a combination of four distinct inbred lines.

These inbred lines are the basis of all commercial hybrid seed corn production. It is essential in any hybrid corn breeding program to develop large numbers of such lines. They are isolated from ordinary open-pollinated varieties by bagging ear shoots of selected plants and, at the proper time, pollinating the silks with pollen from the same plants. The various steps in pollination are shown in Figures 6 through 9. Seed from these selfed ears are planted and the self-pollination process is repeated as before; selection is practiced for such characters as grain quality, ear type, strength of stalk, root system and resistance to insects and diseases. After 5 or 6 years of such inbreeding, which is more highly concentrated than brother-and-sister mating in livestock, inbred strains are produced that possess one characteristic never before found in corn—complete uniformity. Unfortunately, however, the inbreeding process reduces the vigor and productiveness of the strains to less than half that of the original varieties. Plots of several inbred lines, shown in Figure 10, illustrate the differences between lines as well as the uniformity of plants within lines.

When two inbred lines are crossed, there is an immediate return to the vigor of the original varieties, accompanied by the uniformity of the parental inbreds. The discovery that a higher yield than that of either of the original varieties is sometimes obtained from crossing two inbreds, is responsible for the development of the hybrid seed corn industry of today. Literally thousands of inbred lines have been isolated in the hope of finding a few which, when crossed, will give increased yields over open-pollinated varieties. The isolation and identification of a few superior lines require years of work. Five to 6 years are required for the development of the inbred lines, and another 5 to 6 years are needed to identify the lines capable of producing the highest-yielding hybrids.

Figure 6. Bagging ear shoot of a selected plant to prevent pollination by foreign pollen.

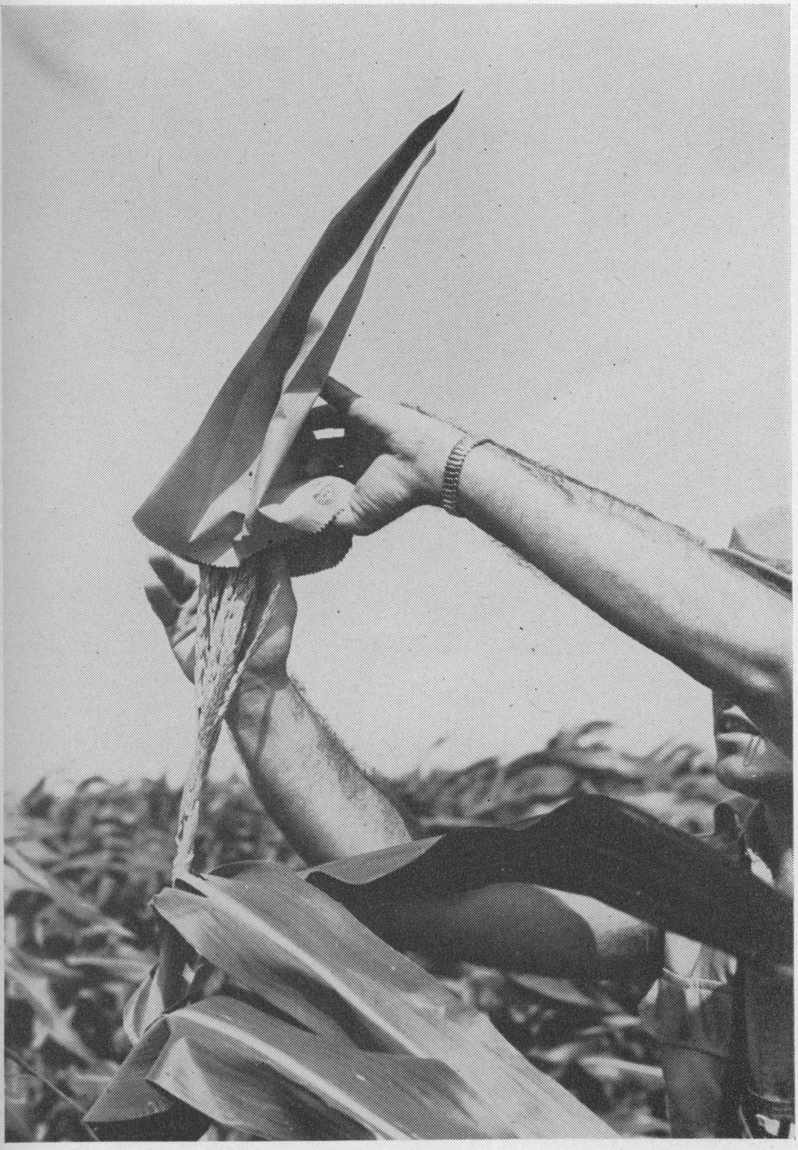

Figure 7. Bagging tassel of a selected plant to collect pollen.

Figure 8. Application of pollen to silks of the ear shoot. The cellophane bag is retained over the ear shoot to prevent contamination by foreign pollen.

Figure 9. Clipping of tassel bag in place over the ear shoot. This bag remains in place until harvest.

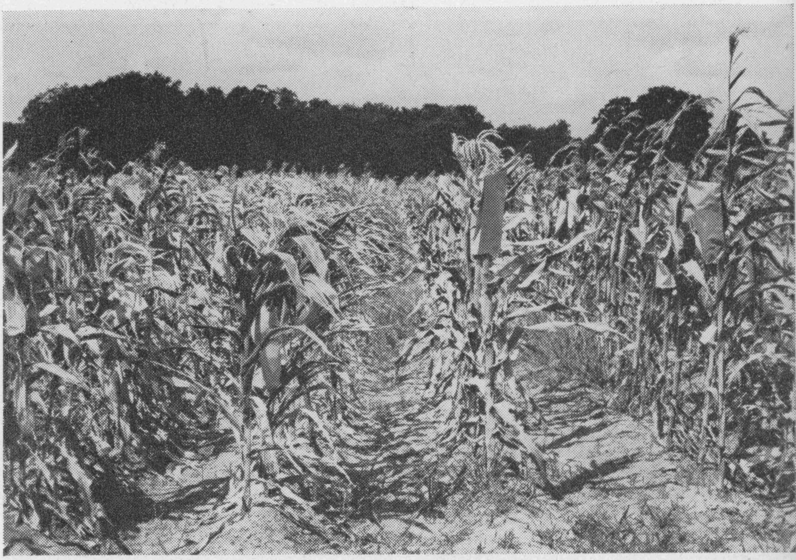

Figure 10. Plots of several inbred lines showing the differences between lines and the uniformity of plants within lines.

Since it is impossible to establish fully the merit of an inbred except by testing it in hybrid combinations, all inbred lines showing promise must be evaluated in a hybrid testing program. This ordinarily is done by crossing the group of untested lines to a common parent, frequently an open-pollinated variety, and conducting a yield test of the resultant hybrids. Such crosses between an inbred line and an open-pollinated variety are known as top crosses. Lines giving the best performance in such tests are then selected for further testing and the others are discarded. When the number of lines has been reduced in this manner, specific combinations among them are produced and tested to determine the best hybrid combinations for use in commercial production. Inbreds selected in this manner for commercial production ordinarily are increased by planting them in fields isolated from other corn by 1,000 to 1,500 feet.

The two types of crosses commonly used in commercial hybrid seed corn production are the single cross and the double cross. The single cross is the first-generation hybrid between two inbred lines. It is also commonly known as a foundation hybrid. The double cross is the first-generation hybrid between two single crosses.

Although a return to vigor and increased productiveness may be obtained in the single cross, the expense of producing such seed prevents the use of single crosses on a scale necessary for farm plantings. Single-cross seed is borne on low-yielding inbred plants and a poor quality of seed is frequently produced. Such production also depends to a considerable extent on favorable weather conditions; this makes single-cross seed production even more hazardous under Texas conditions. For these reasons, the commercial production of hybrid seed is carried one step further to the double cross. In the production of double-cross hybrids, the seed is borne on high-yielding single-cross plants pollinated by other high-yielding single-cross plants and it is, therefore, much cheaper to produce than the single-cross seed. As a result of the use of double crosses, only a limited amount of single-cross seed is required. Although these seed are still quite expensive, the cost to seed corn producers represents only a small portion of the expenses involved in the production of double-cross corn hybrids.

Figure 11 shows the production of a double-cross hybrid, and also gives a comparison of ears produced from both inbred and hybrid plants. Two inbred strains, A & B, are crossed to produce the single cross AB. Two more inbred strains, C & D, are crossed to produce the single cross CD. The following year, AB is crossed by CD to produce a double cross, ABCD, which is a combination of four distinct inbred lines. The procedure is shown better on the back cover in the drawing of the system of crossing involved in producing both the single and double crosses. Single-cross seed is produced on plants A and C as a result of pollination by plants B and D, respectively. This seed, when planted, produces the single-cross plants A x B and C x D, which in turn are hybridized by allowing plants C x D to pollinate plants A x B. The double-cross seed produced by this cross is then planted by the farmer for the production of his commercial crop.

In the field production of either single or double crosses, the actual crossing is done by planting the two stocks alternately in the same field, one as a male, or pollinator, and the other as a female or seed producer. Such fields must be well isolated from all other types of corn to prevent any appreciable degree of contamination. In single-cross production, since the inbred parents are always rather weak, the usual ratio of planting is two seed rows to one pollinator row. Since vigorous single crosses are used in the production of double crosses, however, the ordinary ratio in this case is six or eight seed rows to each two pollinator rows. Before any pollen is shed by the female plants, tassels are removed so

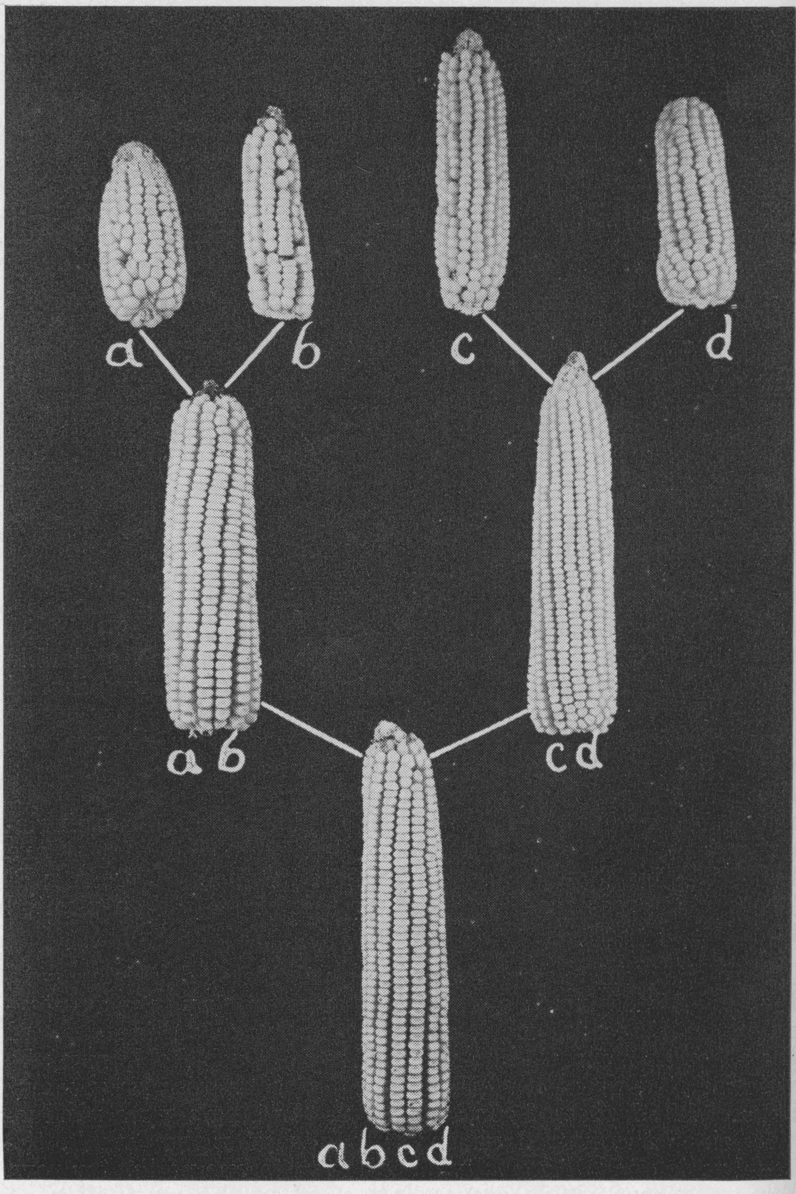

Figure 11. Method of producing single-cross and double-cross hybrids. A, B, C and D are inbreds; AB and CD are the two resulting single-crosses or foundation hybrids; and ABCD is the double-cross hybrid.

that all seed produced will have originated from pollination by only the male plants. This detasseling procedure involves a great deal of hand labor and expense, as it usually is necessary to go through the field pulling tassels every day for 2 to 3 weeks. A detasseled double-cross production field is shown on the cover of this bulletin.

From this description of the procedures involved in the development of corn hybrids, it will be understood why seed of such hybrids is more expensive than that of open-pollinated varieties. In addition, new seed must be purchased each year, since the high-yielding ability is characteristic of hybrid seed only after the first year of crossing. Yields of second-generation hybrid seed, although reasonably good, revert toward the yields of the parental inbreds, and in most instances may be expected to produce about 20 percent less than the first-generation hybrid. On an acre basis, the cost of planting hybrid seed is relatively small. The increased yield more than offsets the additional cost of the seed and will justify the purchase of new seed each year.

TEXAS CORN BREEDING PROGRAM

The Texas corn improvement program was initiated in 1927 by P. C. Mangelsdorf with the inbreeding of several outstanding open-pollinated varieties then grown extensively in the State. This program was based on the isolation of inbred lines through a process of inbreeding and selection, and their subsequent use in the development of synthetic varieties. At that time, corn hybrids had not yet been adopted in even the more important corn-growing areas such as the Midwest. There was some doubt as to whether their use would be feasible in some of the Southern States where corn was not of primary importance.

A large number of inbred lines were developed from several open-pollinated varieties, and a few synthetic varieties were produced by combining some of the more promising inbred lines. This method of breeding did not prove successful, since the synthetic varieties, in general, were no better than the commercial varieties already in use.

Inbred lines developed in the early improvement program did prove to be of considerable value in the production of corn hybrids for Texas. Rapid strides were made from 1930 to 1940 in various parts of the country in the development of corn hybrids, and their usage became well established. During this period, experimental hybrids produced from some of the Texas inbred lines were compared with several of the native open-pollinated varieties. The best of these hybrids produced

TABLE 9. CERTIFIED ACREAGES OF TEXAS CORN HYBRIDS, 1940-51[1]

Hybrid	Acreage											
	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
Yellow												
Texas 4	10	6										
6	10	9										
8		414	404	709	1415	1359	1812	1632	1155	1272	903	170
10			119	78		40	35					
12			474	549	1390	1157	1054	1116	1071	516	466	60
16				265								
18				12	659	1027	1767	2530	2384	2981	1283	496
20						541	907	818	883	815	408	125
22					15	73						
24									412	602	1664	688
26										1036	2404	1464
28										381	1984	1721
30												1290
White												
Texas 1W	5	26										
3W			56	30	12							
7W			81	79	311	50						
9W						225	491	1167	746	667	267	5
11W									445	573	319	626
13W								5	15			
Total	25	455	1134	1722	3802	4472	6066	7268	7111	8843	9698	6645

[1]Data from the State Department of Agriculture, Division of Field Seed Certification, Austin, Texas.

increases in yield of approximately 20 percent over the open-pollinated varieties. These results showed the superiority of adapted hybrids over the ordinary local varieties, and a few of the more promising hybrids were released for commercial production. Since several generations of inbreeding, followed by an additional period of years for testing, were required, it was not until 1940 that Texas hybrids were produced commercially.

The production of Texas hybrids has advanced rapidly since 1940. In 1950 almost 10,000 acres were devoted to seed production. Table 9, giving the certified acreages of the various hybrids, shows the progress of the Texas hybrid seed corn program.

Foundation single-cross seed of all Texas hybrids are produced under the supervision of the Texas Agricultural Experiment Station and are distributed to seed growers for the production of the commercial hybrids. Practically all hybrid seed corn is produced by members of the Texas Certified Seed Corn Association, and all production of Texas hybrids is certified. Seed corn growers accept new hybrids developed by the Experiment Station. These growers have played an important role in making seed of adapted corn hybrids available to farmers throughout the State and in encouraging their use. This is shown in Table 9, with the decided trend toward the newest hybrids, Texas 11W, 24, 26, 28 and 30. Cooperation by the Experiment Station, the Texas Agricultural Extension Service and the Texas Certified Hybrid Seed Corn Association has been largely responsible for the success of the Texas hybrid corn program. Within 11 years after their introduction, Texas hybrids are planted on more than 50 percent of the total Texas corn acreage.

All Texas inbred lines now in commercial use were isolated from native open-pollinated varieties, and hybrids were developed from them in the same general manner as described in the previous section.

To expedite the use of adapted hybrids, both open-pollinated varieties and introduced lines from other states were used in the early phases of the Texas hybrid corn program. For example, Texas 8, released in 1941, is a top cross involving the Yellow Surcropper variety, while Texas 12, released in 1942, utilizes a Kansas single cross as one parent. Both of these hybrids were rather extensively used for several years. With the development of improved hybrids, they are being discarded by growers. Open-pollinated varieties are no longer used in the newer Texas hybrids, although intro-

TABLE 10. DESCRIPTION OF INBRED LINES USED IN TEXAS HYBRIDS

Line	Parent variety	Developing experiment station	Description
4R-3 White	Surcropper	Texas	Medium maturity; medium-sized stalk, medium height; extremely wavy leaves, dark green; anthers cream; silks pink; very good pollen; prolific tendency; medium-sized ears, 14-16 rows; susceptible to lodging.
61M White	Surcropper	Texas	Medium maturity; fairly stout stalk, medium height; fairly narrow leaves, medium green; anthers yellowish-brown; silks red; fair pollen; medium-sized ear, 12-14 rows; good shuck cover; fairly resistant to lodging.
102A White	Blue Grain	Texas	Fairly late maturity; stout stalk, medium height; broad leaves; anthers cream; silks light green; fair pollen; short ear with many rows and poor shuck cover; fairly resistant to lodging.
155A White	Blue Grain	Texas	Early maturity; tall, weak stalk; narrow tapering leaves; anthers cream; silks light pink; fair pollen, prolific tendency; fairly long ear with 12-16 rows; good shuck cover; susceptible to lodging.
K55 White	Pride of Saline	Kansas	Early maturity; short, medium-sized stalk, medium green; silks light green; fair pollen; medium length ear with many rows; small kernels, fair shuck covers; susceptible to lodging.
R11 White	Nicholson's Drought Resister	Illinois	Late maturity; stout stalk, medium height; broad leaves, dark green; silks light green; fair pollen; medium length ear with many rows; small kernels, fair shuck cover; fairly resistant to lodging.
127C Yellow	Mosshart Yellow Dent	Texas	Medium maturity; fairly stout stalk, medium height; pale green leaves which have tendency to blight; anthers cream; silks red; good pollen; short ear with 14-16 rows; large seed, poor shuck cover; susceptible to kernel and ear rots; fairly resistant to lodging.

TABLE 10. DESCRIPTION OF INBRED LINES USED IN TEXAS HYBRIDS (continued)

Line	Parent variety	Developing experiment station	Description
132A Yellow	Mosshart Yellow Dent	Texas	Late maturity; fairly stout stalk, medium to tall; short, fairly broad leaves; anthers pink; silks green; fair-good pollen; fairly long ear, 12-14 rows; chalky seed; poor shuck cover; very susceptible to lodging.
173D Yellow	Mosshart Yellow Dent	Texas	Medium-late maturity; stout stalk, medium height; very broad leaves, dark green; anthers cream; silks light pink; very good pollen; prolific tendency; fairly large ear with 14-16 rows; poor shuck cover; susceptible to lodging.
203 Yellow	Pilgrim Yellow Dent	Texas	Early maturity; slender stalk, medium tall; leaves dull green; anthers green; silks light green; fair pollen; prolific tendency; small ears, 12-16 rows; orange-tinted seed; good shuck cover; susceptible to lodging.
303 Yellow	Yellow Surcropper	Texas	Late maturity; stout stalk, medium green; silks green; heavy tassel, with poor pollen production; ears with large cob and 12-16 rows of grain; fairly large, slightly dull seed; good shuck cover; resistant to ear rots and lodging.
325 Yellow	Yellow Surcropper	Texas	Medium maturity; fairly stout stalk, medium green; silks green; tassel with few branches; fair pollen; short ears with irregular rows; good shuck cover; susceptible to kernel rots; resistant to lodging.
K4 Yellow	Kansas Sunflower	Kansas	Early maturity; slender stalk, dark green; silks green; good pollen; long ears with many rows of grain; very small kernels; fair shuck cover; susceptible to lodging.
Kys Yellow	Kansas Yellow Saline	Kansas	Late maturity; stout stalk, light green; silks green; anthers red; tassel stocky; poor pollen producer; short ears with many rows; small, orange seed; fair shuck cover; susceptible to stalk breaking.

TABLE 11. DESCRIPTION OF TEXAS HYBRIDS

Hybrid	Seed parent	Pollinator parent	Year released	Description
Texas 8[1]	127C x 132A	Yellow Surcropper	1941	An early hybrid which is somewhat irregular in type as a result of an open-pollinated variety being used as one parent. The ears tend to be short but are fairly large in circumference. The kernels are broad but not too deep and are intermediate in type between those of Yellow Surcropper and Yellow Dent. This hybrid is drouth-resistant and well adapted to drier areas and lighter soils. Matures in about 118 days.
Texas 12[1]	127C x 132A	Kys x K4	1942	A hybrid of medium maturity which is uniform in type with ears of medium length and circumference. The kernels are rather small but medium in texture. This hybrid is not drouth-resistant but produces very high yields on good soil with ample moisture. It is susceptible to lodging under adverse conditions. Matures in about 120 days.
Texas 18	173D x 203	127C x 132A	1943	A hybrid of medium maturity which produces rather large, slightly tapering ears, with large, soft, deep yellow kernels. This hybrid performs well under drouthy conditions, but should not be grown in areas of high humidity because of its susceptibility to insects and diseases. It is also quite susceptible to lodging. Matures in about 120 days.
Texas 20	Kys x 203	127C x 132A	1945	A hybrid slightly later than Texas 18; it produces somewhat smaller ears with smaller kernels. It is moderately resistant to ear worms and ear rots but is susceptible to lodging. This hybrid is not particularly drouth-resistant and has produced its best yields in regions of fairly high rainfall. Matures in about 122 days.
Texas 24	325 x 303	K4 x 203	1948	A hybrid of similar maturity to Texas 20. It produces, on the average, larger ears than the other Texas hybrids. In addition, it possesses good shuck protection and is moderately resistant to insects and diseases. The grain is medium hard but fairly large and has a good color. Texas 24 produces stout, vigorous stalks with a strong root system, and is resistant to lodging under most conditions. Matures in about 122 days.

TABLE 11. DESCRIPTION OF TEXAS HYBRIDS (continued)

Hybrid	Seed parent	Pollinator parent	Year released	Description
Texas 26	325 x 203	127C x 132A	1949	An early hybrid which produces medium-sized ears with a yellow dent type grain. The grains are rather large and deep yellow. This hybrid produces two good ears under favorable conditions and shows a wide degree of adaptation. It is somewhat susceptible to ear worms and ear rots and shows a moderate degree of root lodging. Matures in about 118 days.
Texas 28[1]	127C x 132A	325 x 303	1949	A hybrid of medium maturity which produces slightly larger ears than Texas 26, but has the same tendency to make two ears under favorable conditions. The grains are rather large and possess a good yellow color. Texas 28 is somewhat resistant to ear worms and ear rots and ordinarily suffers only moderate damage. Although susceptible to root lodging, it is resistant to stalk breaking. Matures in about 122 days.
Texas 30	173D x 203	325 x 303	1951	A hybrid of similar maturity to Texas 28. It produces large ears with large yellow dent-type grain. Although primarily a one-eared hybrid, it may produce two ears under optimum conditions. Texas 30 is the most resistant of the yellow Texas hybrids to ear worms and ear rots. It is also resistant to root lodging and stalk breaking under most conditions. Matures in about 122 days.
Texas 9W	4R-3 x 61M	102A x 155A	1945	A hybrid of medium maturity. It is semi-prolific. It ordinarily produces two medium-sized ears per plant. The ears are very uniform with tight-set kernels of medium size and texture. This hybrid has excellent shuck covering and is very resistant to ear worms and ear rots. It is susceptible to root lodging. Matures in about 120 days.
Texas 11W	K55 x R11	61M x 155A	1948	A hybrid of about the same maturity as Texas 9W. It produces somewhat larger ears with slightly harder seed. Although primarily a one-eared hybrid, it produces one large and one small ear under favorable conditions. It is moderately resistant to both ear worms and ear rots, and is not as susceptible to root lodging as Texas 9W. Matures in about 120 days.

[1]May be produced reciprocally.

TABLE 12. PERFORMANCE DATA ON CHARACTERS OTHER THAN YIELD, 1948-50

Entry	Root lodging, %	Stalk breakage, %	Unsound ears, %	Worm damage score[1]	Shelling %	Days to silk	Ears per plant
Texas 8	21.8	7.3	7.8	3.1	81.9	79.7	1.1
Texas 12	22.4	10.6	7.8	3.0	82.0	82.6	1.1
Texas 18	26.6	15.3	7.7	3.3	82.9	81.9	1.1
Texas 20	21.9	11.2	6.5	2.7	82.6	82.7	1.1
Texas 24	12.8	4.4	5.1	2.4	82.8	82.4	1.1
Texas 26	22.1	7.7	6.1	2.6	83.2	80.8	1.2
Texas 28	21.8	3.9	5.1	2.4	81.8	82.3	1.1
Texas 30[2]	14.7	4.5	6.1	2.3	82.4	82.0	1.1
Texas 9W	25.4	14.6	4.8	1.9	84.5	81.6	1.1
Texas 11W	22.9	9.5	5.7	2.1	82.0	83.0	1.1
Ferguson's Yellow Dent	25.6	9.9	11.2	2.4	79.9	85.5	.9
Surcropper	23.0	11.2	7.5	2.3	80.6	81.8	1.0
Number of tests included in average	30	19	25	33	9	14	34

[1]Refers to the relative degree of damage to the ears; 1 indicates practically no damage, while 2, 3, 4 and 5 represent successively greater degrees of damage.

[2]Adjusted averages.

duced lines continue to prove useful in the development of adapted hybrids.

Other important Texas hybrids produced during the past 10 years are Texas 18, released in 1942, and Texas 9W and Texas 20, released in 1945. With the exception of Texas 20, which uses one introduced line, these hybrids are produced entirely from Texas inbreds. The yellow hybrids, Texas 24, 26, 28 and 30, which utilize inbreds recently isolated from the Yellow Surcropper variety, are the newest Texas hybrids. These, as well as the white hybrid, Texas 11W, were released from 1948 to 1951, and have produced increases in yield of approximately 10 percent over the earlier Texas hybrids.

A brief description of the inbred lines now used in the Texas hybrids is given in Table 10. Pedigrees and descriptions of the present Texas hybrids are given in Table 11. In addition, data on important characters other than yield are shown in Table 12 for these hybrids and two of the leading open-pollinated varieties. It was necessary to compute adjusted averages for Texas 30, based on the procedure devised by Patterson[1], since this hybrid was included in a smaller number of tests than the other hybrids. Yield data are given in Tables 14 through 18.

Texas 24 and 30 are superior in resistance to root lodging, while Texas 24, 28 and 30 show the greatest resistance to stalk breakage. Texas 24, 28 and 30 should produce corn of better quality than the other yellow hybrids, since they are damaged less by earworms and have fewer unsound ears. Both of the white hybrids, Texas 9W and 11W, are outstanding in resistance to earworms and ear rots. There is very little difference among the hybrids in shelling percentage or maturity, although Texas 26 has the highest shelling percentage of the yellow hybrids and, with the exception of Texas 8, is the earliest. All hybrids are more prolific than the open-pollinated varieties, and Texas 26 is slightly more prolific than the other hybrids. An example of Texas 30's standing ability is shown in Figure 12, where it is compared with one of the older hybrids, Texas 20. Ear samples of Texas 28 and 30, shown in Figure 13, are typical of the ears produced by the newest Texas hybrids.

Continued efforts are being made in the corn breeding program to develop better hybrids than are now available, and new breeding systems are being studied to determine more efficient methods of improvement. Special attention is being devoted to the development of hybrids for areas of the

[1]Patterson, R. E. A method of adjustment for calculating comparable yields in variety tests. Agron. Jour. 42: 509-511. 1950.

State where the present hybrids are not too well adapted. This applies particularly to the Gulf Coast area and the northern and western fringes of the corn-growing region of the State. Resistance to insects and diseases, as well as the ability of plants to stand well under adverse conditions, are also being stressed in the development of improved hybrids. Considerable promising material is now being tested, and present indications are that new and better hybrids will soon be available.

Promising advances have been made in the development of male-sterile inbreds for use in the production of corn hybrids without detasseling. Pollen fails to develop properly in these male-sterile plants, and the tassels have a rather thin, flattened appearance. Since such plants shed no pollen, detasseling will not be necessary when they are used as the seed parents in the production of corn hybrids. Typical fertile and sterile tassels are shown in Figure 14.

Although several years are required to transfer the male-sterile character into the inbreds used in adapted hybrids, the work in Texas has progressed to such an extent that male-sterile seed parents will soon be available for use by seed

Figure 12. Experimental plots showing Texas 30 (left) standing and Texas 20 (right) with a high percentage of lodged plants.

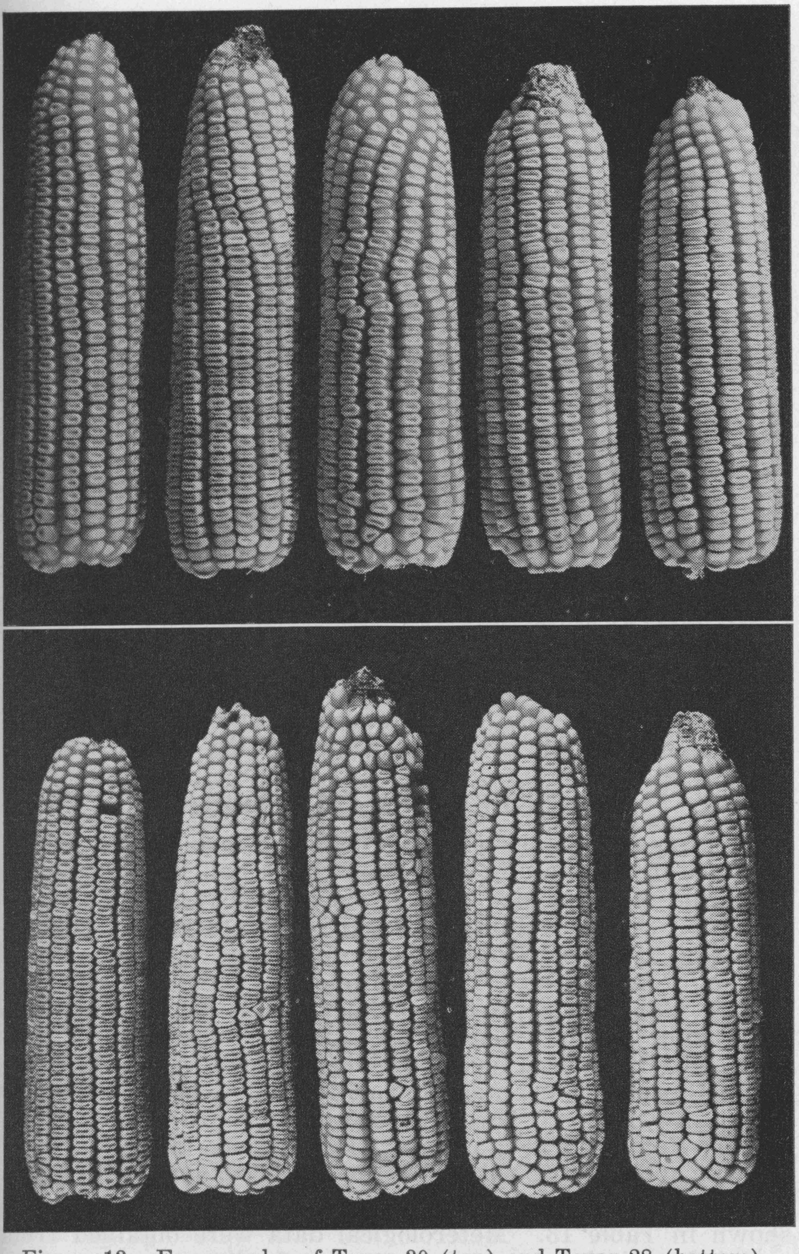

Figure 13. Ear samples of Texas 30 (top) and Texas 28 (bottom).

Figure 14. Fertile tassel (left) sheds abundant pollen while sterile (right) sheds no pollen.

growers. Since detasseling costs ordinarily vary from $10 to $15 per acre, the use of such male-sterile material should effect a considerable saving in the production of corn hybrids.

CORN PERFORMANCE TESTS

Corn performance tests are conducted each year at several locations in the State to determine which hybrids or varieties should be recommended for particular areas. Most tests are grown on the substations, although some are grown with cooperating farmers. Substation tests include those at College Station, Nacogdoches, Tyler, Angleton, Temple, Greenville, Denton, Stephenville, Weslaco, Beeville, Chillicothe and Lubbock, while tests on cooperating farms are located at Kirbyville, Mt. Pleasant, Cleveland, Lockhart, Brenham, Holland, Mart, Garland, Paris and Gatesville. The test locations are shown in Figure 4. Most tests are located in the East Texas Timber Country and Blackland Prairie, since these two areas contain at least two-thirds of the total Texas corn acreage.

Soil types and meterological data of all test locations are shown in Table 13. Meterological data were obtained from each substation, but where tests were grown on cooperating farms, with one exception, data were used from the county

TABLE 13. SOIL TYPES AND METEOROLOGICAL DATA OF LOCATIONS AT WHICH TESTS WERE CONDUCTED

Test location	Soil types	Rainfall			Length of growing season			
		Length of record, yrs.	Inches		Length of record, yrs.	Average no. of days	Average date	
			Average annual	Average for[1] growing season			Last killing frost in spring	First killing frost in fall
College Station[2]	Miller clay	5	41.09	18.97	9	253	Mar. 6	Nov. 14
Kirbyville	Bowie fine sandy loam	22	49.36	21.93	12	242	Mar. 16	Nov. 13
Nacogdoches	Nacogdoches and Bowie fine sandy loams	35	49.36	22.04	34	248	Mar. 13	Nov. 16
Tyler	Kirvin and Bowie fine sandy loams	46	44.82	20.58	46	249	Mar. 15	Nov. 19
Mt. Pleasant	Kirvin fine sandy loam	29	43.87	20.18	26	228	Mar. 25	Nov. 8
Angleton	Lake Charles clay	37	48.34	19.88	37	281	Feb. 25	Dec. 3
Prairie View	Hockley fine sandy loam	42	40.45	17.79				
Cleveland	Hockley fine sandy loam	42	51.15	22.26	39	261	Mar. 7	Nov. 23
Lockhart	Houston Black clay	60	31.95	14.69	52	268	Mar. 3	Nov. 26
Brenham	Houston Black clay	60	39.90	17.35	54	260	Mar. 2	Nov. 17
Holland	Austin clay	60	34.43	16.34	53	257	Mar. 10	Nov. 22
Temple	Austin clay and Houston Black clay	38	34.77	15.86	37	250	Mar. 16	Nov. 21
Mart	Wilson clay loam	64	35.04	17.12	54	244	Mar. 11	Nov. 10
Garland	Houston Black clay	50	36.16	18.39	57	250	Mar. 18	Nov. 23
Greenville	Hunt clay	30	41.46	20.25	30	236	Mar. 21	Nov. 12
Paris	Crockett fine sandy loam and Wilson clay loam	60	40.30	20.37	52	241	Mar. 19	Nov. 15
Gatesville	Denton clay—shallow phase	36	33.20	15.88	26	235	Mar. 21	Nov. 11
Denton	Denton and San Saba clays	38	33.23	16.01	37	243	Mar. 15	Nov. 13
Stephenville	Windthorst and Stephenville fine sandy loams	6	30.60	13.98	6	248	Mar. 15	Nov. 18
Weslaco	Willacy and Hidalgo fine sandy loams	36	23.58	10.04	25	329	Jan. 25	Dec. 20
Beeville	Clareville clay loam	47	30.40	14.38	45	294	Feb. 16	Dec. 7
Chillicothe	Abilene loam and Miles fine sandy loam	45	24.54	13.47	37	232	Mar. 24	Nov. 11
Lubbock	Amarillo fine sandy loam	40	18.90	10.41	40	211	Apr. 7	Nov. 4

[1]March through July, except for Chillicothe and Lubbock, where the growing season is from April through August.
[2]Brazos River Valley Laboratory.

seat of the county in which the test was conducted. The data shown for Kirbyville were obtained from Sabine county, which is the nearest county having such information available.

Table 13 shows the higher total and seasonal rainfall received by the East Texas and Gulf Coast locations, in contrast with that received by the Blackland and Grand Prairies locations. Rainfall is extremely low in the other areas. Length of growing season is relatively similar for all locations, decreasing gradually from south to north. The seasons are of ample length, however, for the proper maturing of corn at each location.

Description of Tests

Since the corn performance tests are conducted primarily as a basis for hybrid and varietal recommendations, all important hybrids and varieties offered for sale to Texas farmers were included. Those showing promise in the initial tests were continued for further testing, while those with a poor degree of adaptation were discontinued. The better-adapted hybrids ordinarily were tested for several years to determine their relative performance. Some hybrids and varieties were continued in tests only at locations where they proved to be adapted. A gradual turnover in entries has occurred between 1941 and 1950, as a result of the introduction of new hybrids.

The actual number of entries included in these tests has varied to some extent. From 1941 through 1946, the numbers were larger, usually ranging from 36 to 64, since a large number of experimental hybrids were included in addition to the commercial entries. Beginning in 1947, all tests were reduced to 25 entries or less and confined almost entirely to commercial entries, only a few of the most promising experimental hybrids being included for comparison with current commercial hybrids.

Insofar as possible, performance tests at each location were grown according to recommended practices for that area. While it was not always possible to obtain optimum conditions, particular attention was given to the use of improved cropping systems, proper cultural methods, adequate fertilization and optimum spacing. The yields obtained in the different performance tests, which are considerably higher than the average for the areas in which the tests are located, bear ample testimony that the tests were grown under much more favorable conditions than most of the corn acreage.

Some variation exists in plot size among the performance tests. Most of the tests were planted in two-row plots, either 1/100 or 1/110 acre in size. In practically all instances, at least 60 plants per plot were obtained, and in no case did the number go below 40. All tests were planted at excessive rates and thinned to one stalk per hill. Spacings of 18 to 24 inches were commonly used, although 30 or 36-inch spacings were used at some of the drier locations. Figure 15 shows typical examples of performance test plots with Texas 30 and Ferguson's Yellow Dent growing in the 1950 test at College Station. This figure also shows the increased yield obtained when an adapted hybrid is compared with an open-pollinated variety.

Simple lattice designs with four replications were used in practically all corn performance tests from 1941 to 1950. A few of the smaller tests were planted in randomized block designs. Six-replicate triple lattice designs were used in a few instances where considerable soil variability existed. All lattice designs were analyzed as such, and yield adjustments were made when significant gains in precision were obtained. Where no gain in precision was obtained, randomized block analyses were used.

Yields of all tests are reported in bushels of shelled corn per acre. Shelling percentages were obtained by shelling

Figure 15. Plots of Texas 30 (left) and Ferguson's Yellow Dent (right) in the performance test at College Station. Note the greater yield of Texas 30.

Figure 16. Field weighing scene of an individual corn performance test plot.

all the ears from one replicate of each entry. Since it was not always possible to shell a replicate of each individual test, it was necessary in some instances to utilize shelling percentages obtained from a comparable test. All yields are based on air-dry field weights, since each entry had ordinarily reached a moisture equilibrium around 13 or 14 percent by the time of harvest. Some bias may have been introduced occasionally as a result of variable moisture content among entries, but it was deemed so slight that the additional expenditure of time and effort required in taking individual moisture samples did not appear warranted. An actual field-plot weighing scene is shown in Figure 16.

Discussion of Results

Results of performance tests from 1941 to 1950 at 23 locations over the State are summarized in Tables 14 through 18. All available yield data were utilized in computing these summaries. Data for the entire 10-year period, however, were available for only a few locations. Many tests were initiated after 1941, and unfavorable environmental conditions caused test failures at some locations each year. Detailed annual results for each location are not presented in this bulletin, but such information in mimeographed form is available on request to the Texas Agricultural Experiment Station, College Station, Texas.

Comparable averages were used in comparing the entries over a period of years, since all entries were not included for the entire period in which tests were conducted. Such averages were computed according to the procedure devised by Patterson[2], whereby the entries grown for less than the full period are adjusted on the basis of the annual average of those grown in all years. The number of years tested and the rank in yield of each entry are included. Results for one year do not provide a reliable index to their yielding abilities. Recommendations should be based only on the performance of entries grown for several years.

Results of the performance tests at the various locations are discussed following by soil areas, to provide a general basis for their consideration.

East Texas Timber Country

Only limited testing has been conducted in the southern part of this area, but the results so far indicate that Texas 28, 26 and 24 will produce good yields. Since diseases and insects are important factors in this section, Texas 24 and 30 should be given special consideration because of their resistance to both types of organisms. On the basis of several years' results at the Brazos River Valley Laboratory, Texas 28, 26 and 24 are recommended for planting on alluvial soils of the area. Texas 28 and 26 produced the highest yields at Nacogdoches in the central part of the area, while Texas 20 has been outstanding in yield in the northeastern section. Texas 30 and Keystone 222 also gave good results at Tyler in the single year tested, while Texas 26, 24 and 28 made good yields for at least a 3-year period. Texas 26 is recommended for light, sandy soils of the entire area where drouth conditions may be severe. Texas 11W has given the best results of any white hybrid in the area.

Gulf Coast Prairie

Commercial hybrids have not proved to be well adapted in the lower part of the Gulf Coast, primarily because of their susceptibility to insects and diseases. Consequently, the Tuxpan and Yellow Tuxpan varieties are still planted on a considerable acreage. Results at Angleton, which is the only test location on clay soils in the Gulf Coast Prairie, indicate that the white hybrids, Texas 11W and 9W, are the best adapted of the Texas hybrids to the lower Gulf Coast. For the sandy, better-drained areas, Texas 20, 24, 26 and 28 are

[2]Op. cit.

recommended on the basis of their performance at Prairie View and Cleveland. Texas 24 and Texas 30 should receive special consideration for the entire area because of their superior resistance to insects and diseases.

Blackland Prairie

When results are considered from the numerous tests conducted in the Blackland area, Texas 28 and 26 are, on the average, the highest yielding hybrids over a period of years. Texas 24 has also given satisfactory results, although it has generally yielded below the other two hybrids. Texas 30 has shown promise in limited tests, as did Watson 124 in the single year it was tested. Texas 11W has performed very well in the area over a period of years, but it has not yielded as well as the yellow hybrids. Texas 26 is recommended especially for the more drouthy soils of the area.

Grand Prairie

Tests conducted for the entire 10-year period at Denton, in the northern part of this region, show that Texas 28, 26 and 24 will produce high yields. Similar results have been obtained in the southern part at Gatesville for a 3-year period. Texas 26 in particular, because of its slightly earlier maturity, is recommended for lighter soils where drouth conditions are more severe.

West Cross Timbers

At Stephenville, the only location in this area where tests have been conducted, Texas 28 produced the highest average yield over a period of years. Texas 11W, Texas 26 and United U72 also were among the high-yielding hybrids.

Rio Grande Plain

Tests in the Lower Rio Grande Valley at Weslaco, under irrigation, indicate that Texas 24 is the best-adapted hybrid for these conditions, and that the Tuxpan open-pollinated variety will yield about as well as most hybrids. Since insects and diseases are a serious problem in the Lower Valley, Texas 11W and 30 also are recommended. Texas 24 produced the highest average yield in tests conducted at Beeville under dry-land conditions. Two other hybrids, Texas 26 and Funk G711, also produced high average yields at Beeville over a period of years.

Rolling Plains

Results at Chillicothe, in the eastern part of this area, show very little difference in the performance of several Texas hybrids. Texas 26, 20, 18 and 28 produced good results; Keystone 222 also yielded well for a shorter period.

High Plains

Performance tests conducted at Lubbock indicate that Texas 28 is the best hybrid for the southern High Plains. More extensive tests are needed, however, to provide a basis for recommendations over the entire area.

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APPENDIX

TABLE 14. EAST TEXAS TIMBER COUNTRY—COMPARABLE AVERAGE YIELDS, BUSHELS OF SHELLED CORN PER ACRE, 1941-50

Hybrid or variety	College Station			Kirbyville[1]		Nacogdoches			Tyler			Mt. Pleasant[1]	
	No. years	Yield	Rank	Yield	Rank	No. years	Yield	Rank	No. years	Yield	Rank	Yield	Rank
Texas 8	10	49.6	19	75.7	8	8	28.1	16	9	45.2	17	48.2	6
Texas 12	10	55.6	6	76.7	6	8	30.3	13	9	51.1	7	48.0	7
Texas 18	8	51.4	16	74.4	10	7	27.7	18	8	47.4	11	47.4	8
Texas 20	6	54.1	9	77.2	4	6	30.3	13	6	55.9	2	51.3	3
Texas 24	5	57.3	5	77.2	4	3	33.1	6	4	51.8	5	55.2	1
Texas 26	6	58.6	3	81.8	1	2	34.0	2	4	52.0	4	50.5	4
Texas 28	4	57.8	4	77.8	3	3	34.8	1	3	51.3	6	49.6	5
Texas 30	2	61.2	1						1	55.3	3		
Texas 9W	7	51.8	14	67.7	13	6	28.8	15	7	45.4	16	42.4	14
Texas 11W	7	55.1	8	75.3	9	4	32.4	8	7	50.6	8	46.9	10
DeKalb 888	2	44.6	25						1	42.4	20		
DeKalb 899	2	45.4	24						1	40.3	22		
DeKalb 1002	3	49.5	20			1	33.2	4	3	39.3	23		
DeKalb 1020	1	46.8	22			1	32.6	7					
DeKalb 1022	5	48.1	21			3	22.7	22	3	44.8	19		
DeKalb 1025	4	51.0	17	68.5	12	2	32.0	9	2	46.6	13	46.6	11
Dixie 11	2	52.8	12			1	30.6	12	1	34.5	30		
Funk G702	3	44.2	26						2	38.4	25		
Funk G711	9	55.6	6	66.1	14	7	31.3	10	8	50.2	9	53.1	2
Funk G715	1	46.3	23	76.3	7	1	33.7	3	2	48.8	10		
Funk G716	3	51.9	13						4	46.8	12		
Funk G788W				68.8	11	2	27.8	17					
Kansas 2234	2	51.8	14						2	41.2	21		
Keystone 222	1	58.9	2	79.2	2				1	56.4	1		
Louisiana 468	1	42.4	28										
TRF 3						1	27.4	19					
United U72	5	49.8	18			2	20.2	25	4	45.0	18		
United U75	5	53.7	10						3	46.3	14		
United U79	6	53.2	11	65.3	15	4	30.8	11	4	46.3	14	46.4	12
Watson 124						1	33.2	4					
Denco Yellow Dent	5	41.4	30						3	38.6	24		
Fain's White Dent						1	16.9	27					
Ferguson's Yellow Dent	10	42.0	29	55.1	19	7	21.9	23	9	34.6	29	32.4	15
Golden June									1	32.3	31		
Hasting's Prolific						6	25.7	20					
Mexican June									1	30.7	33		
Mickle's Yellow Dent	6	39.8	32						2	37.3	27	44.8	13
Reese Drought Resister	6	37.6	34						4	29.9	34		
Surcropper	10	42.8	27	62.9	16	6	21.7	24	9	35.6	28	47.2	9
Texas Golden Prolific	3	39.3	31			7	25.4	21	8	38.1	26		
Tuxpan				61.2	17								
Yellow Surcropper	7	38.7	33			5	18.2	26	6	31.2	32		
Yellow Tuxpan				57.7	18								

[1]Tests grown for only one year.

TABLE 15. GULF COAST PRAIRIE—COMPARABLE AVERAGE YIELDS, BUSHELS OF SHELLED CORN PER ACRE, 1941-50

Hybrid or variety	Angleton			Cleveland[1]		Prairie View[1]	
	No. years	Yield	Rank	Yield	Rank	Yield	Rank
Texas 8	5	30.2	15	61.7	12		
Texas 12	5	29.8	16	68.7	7		
Texas 18	3	32.9	5	68.8	6	33.1	4
Texas 20	2	28.8	19	75.6	1	29.5	6
Texas 24	1	31.9	9	68.0	8	33.2	3
Texas 26				68.9	5	32.7	5
Texas 28	1	31.4	11	73.7	2	26.1	11
Texas 9W	3	36.5	4	58.9	15	26.7	10
Texas 11W	2	40.6	3	61.3	13	25.9	12
DeKalb 1002	1	31.5	10				
DeKalb 1008	1	18.0	31				
DeKalb 1022	1	26.8	22				
DeKalb 1025						34.8	1
Dixie 11	1	42.6	1	70.9	4		
Dixie 18	1	28.9	18				
Funk G711	4	28.4	20	62.0	11	34.8	1
Funk G716	2	31.1	13	60.4	14		
Funk G721	1	32.9	5				
Funk G737	1	31.4	11	65.5	9		
Funk G788W	1	42.4	2			28.6	7
Keystone 101W				71.2	3		
United U70				54.6	19		
United U72	1	26.2	23	58.7	16		
United U75	1	22.6	27				
United U79	2	32.6	8			26.8	9
Denco Yellow Dent	1	21.5	29				
Ferguson's Yellow Dent	6	22.3	28	52.4	20	13.6	15
Golden June	5	25.0	25				
Mexican June	4	32.8	7				
Reese Drought Resister	5	25.5	24				
Surcropper	6	27.6	21	51.8	21	25.8	13
Texas Golden Prolific	2	20.3	30	55.2	18		
Tuxpan	6	31.1	13	65.0	10	24.5	14
Yellow Surcropper	5	24.6	26				
Yellow Tuxpan	6	29.0	17	58.5	17	26.9	8

[1]Tests grown for only one year.

TABLE 16. BLACKLAND PRAIRIE—COMPARABLE AVERAGE YIELDS, BUSHELS OF SHELLED CORN PER ACRE, 1941-50

Hybrid or variety	Lockhart			Brenham			Holland			Temple			Mart			Garland			Greenville			Paris		
	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank
Texas 8	5	55.2	8	3	51.6	14	6	38.0	8	9	39.4	12	3	35.2	12	5	43.1	12	4	31.8	16	2	34.5	10
Texas 12	5	53.0	13	3	49.0	18	6	34.1	25	9	37.4	16	3	33.5	20	5	40.9	19	4	35.9	8	2	34.4	13
Texas 18	5	54.9	9	3	54.1	7	6	38.0	8	8	39.8	11	3	37.3	4	5	43.6	11	4	33.6	14	2	33.6	14
Texas 20	5	56.7	6	3	55.2	5	6	38.1	7	5	41.3	7	3	36.5	7	5	44.9	6	4	37.5	6	2	36.2	6
Texas 24	5	59.2	5	3	57.6	3	4	39.8	4	4	43.7	4	3	37.0	6	4	49.1	3	4	37.7	5	2	34.5	10
Texas 26	5	60.5	3	2	57.3	4	5	40.7	3	5	43.9	3	3	37.2	5	5	48.8	4	4	39.6	3	2	39.8	4
Texas 28	4	63.5	1	3	61.1	1	4	41.7	2	3	44.5	2	3	39.8	1	3	50.2	2	3	38.9	4	2	40.6	3
Texas 30	1	60.2	4							2	45.3	1												
Texas 9W	5	53.4	12	3	51.1	15	6	36.6	12	6	39.0	13	3	34.7	15	5	42.1	17	4	31.2	18	2	32.6	16
Texas 11W	5	56.3	7	3	55.0	6	6	39.0	6	6	42.5	6	3	35.9	9	4	44.0	9	4	34.0	13	2	34.5	10
DeKalb 888										3	32.5	25												
DeKalb 899										2	35.2	22												
DeKalb 1002	1	48.0	21				2	34.9	21	3	37.4	16	1	34.6	16	1	40.2	20	1	29.3	21	1	33.1	15
DeKalb 1008							1	36.6	12				1	31.4	25				1	29.0	23	1	31.0	18
DeKalb 1020	1	48.0	21	1	52.0	9	1	35.6	19				1	27.6	29	1	42.7	15						
DeKalb 1022	3	52.1	15	2	49.0	18	4	35.6	19	5	36.3	21	1	39.0	2	2	41.9	18	2	31.8	16	2	30.2	19
DeKalb 1025	5	50.1	18	3	51.0	16	4	35.8	17	4	38.1	15	2	31.8	24	2	43.0	14	2	34.3	11	2	29.9	20
Dixie 11							1	30.8	28	1	32.0	26							1	25.7	28			
Funk G702										3	36.7	19				1	42.7	15						
Funk G711	5	53.6	11	3	51.9	11	6	37.6	10	8	41.1	8	3	35.0	13	5	43.1	12	3	35.9	8	2	31.2	17
Funk G711A													1	33.8	18									
Funk G715				1	51.9	11	1	36.0	16	1	38.6	14	1	35.7	10							1	35.1	9
Funk G716	3	50.4	17	1	45.5	23	2	35.8	17	3	36.8	18				1	38.9	21	1	29.5	20			
Funk G721													1	32.5	22									
Funk G737																			1	26.5	26			
Funk G788W	1	46.9	24	2	48.8	20	2	27.1	31				2	33.0	21	1	29.4	24	2	35.4	10			
Kansas 2234	2	52.1	15				2	36.2	15	1	31.3	29				1	44.3	7	1	34.3	11			
Keystone 222	2	54.0	10	2	52.4	8	2	39.7	5	1	42.8	5	1	34.0	17	1	43.9	10	1	40.0	2	1	41.4	1
Louisiana 468	1	43.2	28																					
Shannon 1300										1	29.3	34				1	27.9	25	1	26.2	27			
TRF 3				1	52.0	9	1	34.9	21				1	35.3	11				1	36.5	7			
United U71							1	34.8	23															
United U72	4	48.9	20	3	50.1	17	5	36.6	12	5	40.0	10	3	36.2	8	5	46.6	5	3	30.0	19	1	35.9	8
United U74													1	35.0	13							1	37.7	5
United U75	3	52.4	14	1	51.7	13	1	34.3	24	5	36.6	20	2	32.1	23	4	44.3	7						
United U77				1	48.7	21							1	33.7	19									
United U79	4	49.6	19	1	46.0	22	6	37.6	10	7	40.4	9	1	30.2	27	4	38.8	22	3	28.5	24	2	36.2	6
Watson 124	1	63.5	1	1	60.5	2	1	42.1	1				1	37.6	3	1	50.3	1	1	41.3	1	1	41.3	2
Denco Yellow Dent										5	30.1	31												
Ferguson's Yellow Dent	5	43.8	27	3	38.6	26	6	28.4	30	9	29.5	33	3	27.9	28	5	27.9	25	3	20.2	29	1	25.7	22
Golden June										4	29.6	32												
Kreid Yellow Dent	1	46.0	25	1	42.7	25	1	19.6	33							1	25.1	27						
Mickle's Yellow Dent										6	31.4	28							1	28.5	24			
Nelson's Native							3	25.2	32	4	33.9	24												
Pfluger's Giant Yellow Dent	1	45.0	26				2	29.7	29															
Reese Drought Resister	1	40.7	29							6	31.9	27												
Surcropper	5	47.7	23	2	44.4	24	5	32.7	26	9	34.5	23	3	31.2	26	5	38.0	23	4	29.1	22	2	28.8	21
Yellow Surcropper	2	37.4	30				3	32.3	27	7	30.7	30							1	32.1	15			

TABLE 17. GRAND PRAIRIE AND WEST CROSS TIMBERS—COMPARABLE AVERAGE YIELDS, BUSHELS OF SHELLED CORN PER ACRE, 1941-50

Hybrid or variety	Grand Prairie						West Cross Timbers		
	Gatesville			Denton			Stephenville		
	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank	No. yrs.	Yield	Rank
Texas 8	3	31.4	12	10	35.4	11	8	26.9	14
Texas 12	3	31.3	13	10	36.3	9	8	26.7	15
Texas 18	3	32.6	5	8	36.6	8	7	29.0	8
Texas 20	3	33.2	4	6	38.2	4	6	29.1	7
Texas 24	3	35.2	2	5	39.7	3	4	29.6	6
Texas 26	3	36.9	1	6	40.1	2	3	30.4	4
Texas 28	2	34.8	3	4	40.3	1	4	32.7	1
Texas 9W	3	30.6	16	7	34.2	14	6	27.6	12
Texas 11W	3	31.5	10	7	35.0	13	4	30.6	3
DeKalb 888				3	25.1	32			
DeKalb 899				2	27.8	28			
DeKalb 1002	1	32.0	8	5	33.7	16			
DeKalb 1008	1	31.2	15				2	28.4	9
DeKalb 1020	1	30.3	17						
DeKalb 1022	2	31.5	10	6	32.2	20	2	26.2	17
DeKalb 1025	2	29.6	18	3	35.8	10	1	31.3	2
DeKalb 919W				1	26.2	31			
Dixie 11	1	20.0	31	1	27.8	28			
Funk G87				1	30.0	23			
Funk G702				2	30.0	23			
Funk G711	3	32.0	8	9	34.2	14	6	26.5	16
Funk G715	1	32.4	6	1	37.2	7	1	27.4	13
Funk G716	1	23.1	29	3	30.8	22	2	27.8	11
Funk G788W	1	24.4	28						
Kansas 2234	1	31.3	13	2	32.4	21			
Keystone 222	2	27.8	20	2	37.4	5			
United U72	3	27.9	19	5	35.4	11	4	30.4	4
United U75				5	32.6	19			
United U77	1	32.4	6						
United U79	3	26.9	22	8	32.8	18	2	28.0	10
Shannon 1300	1	24.8	27	1	28.5	25			
TRF 3				1	33.7	16			
Watson 124				1	37.4	5			
Denco Yellow Dent	1	26.7	23	6	24.1	35	2	19.6	22
Ferguson's Yellow Dent	3	25.0	25	10	24.7	34	7	17.8	23
Golden June				1	18.5	36	7	23.3	18
Kreid Yellow Dent	1	21.4	30						
Mickle's Yellow Dent	1	24.9	26	3	27.9	27			
Reese Drought Resister				6	24.8	33	4	21.2	21
Surcropper	3	27.3	21	10	28.0	26	8	22.9	19
Yellow Surcropper	1	25.8	24	7	27.2	30	4	22.5	20

TABLE 18. RIO GRANDE, ROLLING AND HIGH PLAINS—COMPARABLE AVERAGE YIELDS, BUSHELS SHELLED CORN PER ACRE, 1941-50

Hybrid or variety	Rio Grande Plain						Rolling Plains			High Plains		
	Weslaco			Beeville			Chillicothe			Lubbock		
	No. years	Yield	Rank	No. years	Yield	Rank	No. years	Yield	Rank	No. years	Yield	Rank
Texas 8	1	57.2	17	9	29.0	5	10	26.2	12	6	24.8	8
Texas 12	5	66.6	11	9	28.4	9	10	27.4	6	5	24.0	10
Texas 18	2	76.2	2	7	29.0	5	7	28.5	4	5	24.2	9
Texas 20	3	61.9	13	5	28.5	8	6	28.7	3	3	26.3	5
Texas 24	2	86.5	1	4	31.2	1	4	26.4	10	2	27.9	2
Texas 26	1	69.5	6	5	29.9	3	4	28.9	2	3	26.9	4
Texas 28	1	67.4	9	3	27.6	14	3	28.1	5	2	31.2	1
Texas 9W	5	60.5	15	6	25.7	20	6	25.8	13	2	22.6	14
Texas 11W	3	75.5	3	6	27.4	15	4	26.3	11	3	26.0	6
DeKalb 888				2	19.2	32						
DeKalb 899				2	25.8	19						
DeKalb 1002				3	28.1	11	3	27.0	8			
DeKalb 1008				2	28.0	13						
DeKalb 1022	1	68.9	7	4	28.1	11	3	24.9	16	3	25.9	7
DeKalb 1025				2	30.8	2	2	24.6	17			
Funk G702				2	27.2	16						
Funk G711	2	66.7	10	8	29.9	3	8	26.8	9	4	23.7	11
Funk G715	1	71.0	5									
Funk G716	1	61.7	14	3	28.2	10	3	24.2	18	2	22.8	12
Funk G788W	1	62.6	12									
Kansas 2234				2	23.5	21	1	27.4	6	1	22.7	13
Keystone 222							2	29.0	1			
Shannon 1300							1	25.1	15			
United U72				4	26.7	17	5	25.2	14	3	21.7	16
United U75				5	26.0	18	1	22.6	20			
United U79	1	60.2	16	5	29.0	5	6	23.9	19	1	27.0	3
Denco Yellow Dent				5	22.3	24	3	21.3	22			
Ferguson's Yellow Dent				9	20.7	29	10	17.4	26			
Golden June				9	22.1	25	10	21.7	21	6	22.0	15
Golden Thomas				9	20.8	28						
Mexican June				7	21.1	26	7	18.6	24	4	21.6	17
Mickle's Yellow Dent				5	23.4	22						
Reese Drought Resister				6	19.4	31	6	16.1	27	3	18.4	20
Surcropper				9	22.8	23	10	18.2	25	6	21.6	17
Thomas				9	20.0	30						
Tuxpan	7	72.6	4									
Yellow Surcropper				7	21.0	27	7	19.2	23	4	21.0	19
Yellow Tuxpan	6	68.7	8									

MORE DETAILS AVAILABLE

Detailed annual yields on performance tests at 23 locations are available in a separate mimeographed report. Copies of these tables may be obtained from the Publications Office, Texas Agricultural Experiment Station, College Station, Texas.

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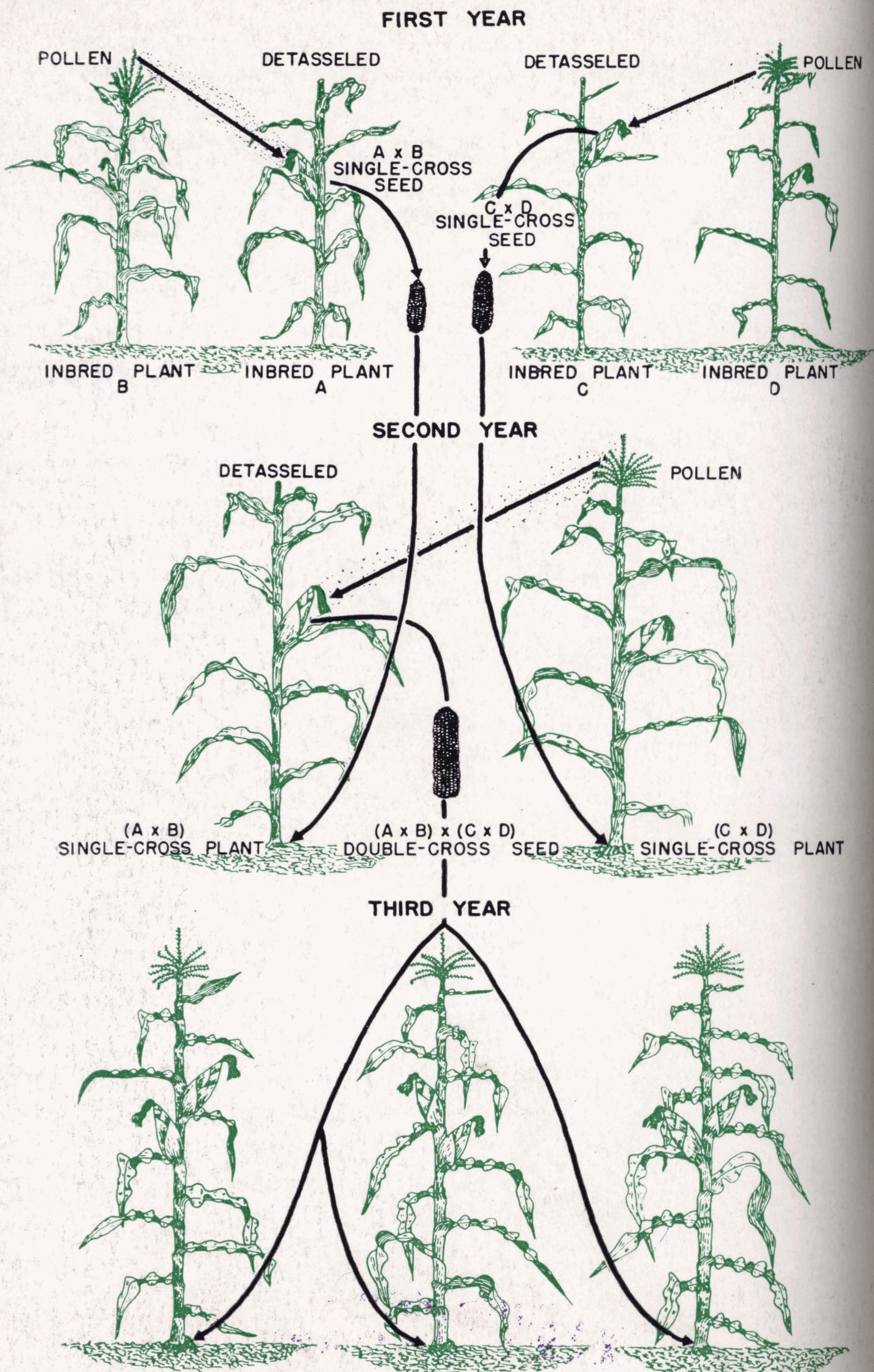

Method of producing single-cross and double-cross corn hybrids.